THE ENGINEER

A Seven-Day Journal

The Ministry of Materials

THE text of a Bill "to make provision for the appointment and functions of a Minister of Materials" was issued on Friday last, together with an explanatory memorandum in the form of a White Paper. The Lord Privy Seal, Mr. R. R. Stokes, is to take charge of the new Ministry. The White Paper says that the function of the Minister of Materials will be to do everything possible to ensure adequate supplies of those materials with which he is concerned. He will, where appropriate, take steps to increase the production of materials in short supply; to promote their economical use, salvage and recovery, and to develop the production and use of substitutes. The White Paper explains that the Minister of Materials will take over the responsibility of the Minister of Supply for the supply of non-ferrous and light metals in unwrought forms, with certain exceptions. As far as iron and steel are concerned, however, the Government feels that one department should be responsible for the industry as a whole, and that any attempt to distinguish between the basic raw materials and iron and steel at different stages of fabrication would cause serious inconvenience. The Minister of Supply, therefore, will retain responsibility for the iron and steel industry. He will also retain responsibility for manganese ore, ferro-manganese and ferro-alloys generally, and other derivatives of tungsten and molybdenum, and for the non-ferrous and light metal fabricating industries. The Board of Trade's responsibilities for the basic raw materials of the chemical industry are to be taken over by the Minister of Materials, although the Board of Trade will continue to deal with the chemical industry generally.

Rural Water Supplies and Sewerage

THE Rural Water Supplies and Sewerage Bill, which was presented to the House of Commons on Wednesday, June 13th, is designed "to increase to £45,000,000 the limit of £15,000,000 on the contributions out of moneys provided by Parliament which may be made under Section 1 of the Rural Water Supplies and Sewerage Act, 1944." The 1944 Act authorised £15,000,000 for grants to help English and Welsh local authorities in carrying out rural water supply and sewerage schemes. By reason of the fact, however, that the comprehensive schemes being planned and carried out take many months to complete, the amount actually paid so far to local authorities is about £3,000,000. The new Bill imposes a maximum direct charge on the Exchequer of £30,000,000. But the rate at which schemes will be carried out will be controlled by the capital investment programme and the amounts which can be allocated within that programme to rural water supply and sewerage. It is estimated that, at the present rate of progress, the total expenditure towards which grants will be payable will be of the order of £90,000,000, spread over a period of seven years.

A Tunnel Driving Record

SOME high rates of progress of rock tunnelling have recently been achieved in driving tunnels for the collecting aqueducts of the Loch Sloy hydro-electric scheme of the North of Scotland Hydro-Electric Board. During the week ended Sunday, June 10th, tunnellers working eight-hour shifts round the clock for seven days drove a distance of 427ft through hard diorite rock forming the mountains of the Cobbler Range. This is said to be the first time a footage of over 400ft has been driven in Great Britain, the previous best figure of 334ft being achieved recently during the construction of the Bowland Forest tunnel of the Manchester Corporation's waterworks scheme for the Haweswater aqueduct. Altogether, over a period of thirty-one working days a total footage of 1231ft has been driven at Loch Sloy. The tunnel is approximately 7ft square and will be some 6000ft long when completed. It will carry water from above the Rest-and-Be-Thankful summit to the Loch Sloy reservoir to increase the catchment supplying the reservoir. The work is being carried out by Edmund Nuttall, Sons and Co. (London), Ltd., for the North of Scotland Hydro-Electric Board, the consulting engineers being Messrs. James Williamson and Partners.

The National Maritime Museum

THE hull of "Miss Britain III" is now on view, alongside other unique exhibits, in Neptune's Hall at the National Maritime Museum at Greenwich. Most boats, after a term of years, find their way into the hands of the shipbreaker, but that is not to be the fate of Mr. Hubert Scott-Paine's historic example of boat building and marine engineering, which has been accepted by the trustees of the Museum. "Miss Britain III," which was the first motor boat of all-metal construction, was in 1933 the medium for the installation of the first aero-engine, a Napier "Lion," converted for marine propulsion. The reliability of the engine conversion and the stability of the hull were fully tested when challenging for the Harmsworth Trophy in 1933. The series was won by a narrow margin by the American boat, "Miss America X," which was driven by four Packard engines developing nearly four times the horsepower of the challenger. The Napier engine conversion was the prototype of all engines, including the Rolls-Royce "Merlin" and the "Packard," similarly converted and employed in the development during the last war of the motor torpedo and motor gunboats of the Royal Navy and the air/sea rescue launches of the Royal Air Force. The design was adopted in America and many boats known as the "P.T." type were built from the drawings of these boats.

H.M. Submarine "Affray"

AFTER an intensive search by a number of vessels, H.M. Submarine "Affray" was found on June 14th, some fifty-nine days after submerging, with seventy-five officers and men on board, off the Isle of Wight, on Monday night, April 16th, to carry out a practice patrol. According to the Admiralty statement, the "Affray" was located, by asdic, lying on the lip of the Hurd Deep in 258ft of water at a point about 37 miles south-west of her diving point, and in a new search area described as an area of relative improbability. A diver from the submarine rescue ship "Reclaim" was lowered at the spot in a diving compartment equipped with a searchlight and was able to establish the identity of the submarine and that she was lying on an even keel. Later examinations have shown that all hatches are closed, indicator buoys housed, and rudder and hydroplanes undamaged with the latter set to rise. However, it was found that the snort was broken at the heel and hanging over the port side, and in it was a large hole through which water could gain access to the engine-room. The establishment of the actual position of the vessel brings to a close the first phase of the operations and opens up the difficult question of salvage, but before any decisions can be made and plans drawn up it will be necessary to carry out a survey to establish the condition of the submarine. Diving operations for this purpose will occupy some time, because strong tidal currents limit the periods available for investigation to a short time either side of slack water. The actual depth of water is not an insurmountable difficulty, as submarines have been raised from greater depths, including the United States submarine "F.4." But other factors may influence the Admiralty with regard to the methods of salvage, if salvage is a possibility.

The Work of the Patent Office

THE sixty-eighth report of the Comptroller-General of Patents, Designs and Trade Marks, which has just been published as a White Paper, reviews the work of the Patent Office during the year 1950. The total number of patent applications filed last year was 31,686, or nearly 2000 less than in either of the two preceding years, and the number of patents sealed was 13,509, compared with 20,703 in 1949. The report explains, however, that the decrease can be attributed mainly to the initial operation of the Patents Act, 1949, which took effect on January 1, 1950. Prior to that date the period within which an application could be sealed was determined by the date of acceptance of the specification, whereas under the new provisions it begins from the date of publication, which is approximately two months after acceptance. The new Act also extends by one month the normal period within which an opposition to the grant of a patent may be lodged. Consequently, no patents could be sealed during the period January 1st to March 28th. The report says that the Patent Office still has heavy arrears of work, particularly patent applications awaiting examination. Some concern is felt at the failure of the open competitive examinations to provide a sufficient number of successful candidates to fill existing vacancies on the scientific staff and to enable that staff to be expanded. The trend of invention disclosed by patent specifications examined during the year showed a good deal of activity concerning aircraft capable of flying at near-sonic speeds and at high altitudes, particularly with regard to stability, manœuvrability, drag reduction, boundary layer control of airflow, and pilot ejection apparatus.

British Waterworks Association

ON Wednesday last, Sir William Neill was installed as President of the British Waterworks Association at its annual conference, which is being held at Portrush, Northern Ireland. In his address to the conference, Sir William said that he believed that the Association's impact on the water industry had substantially changed the general attitude to water supplies, and that it was probably the most effective instrument for carrying out those further advances which would assist towards the ultimate solution of most of the present problems. In referring to the recently published report on the "Organisation of the Water Supply Industry," Sir William suggested that whether any Government action was taken or not, there were certain fields in which the Association could itself initiate co-ordinated action. He also considered that the Association might formulate a policy of service to the consumer for the consideration of each water authority. On the subject of water fittings, he said that the Standing Committee on Water Regulations, which worked with the co-operation of and by means of the facilities afforded by the major water undertakings, had for a long time considered the setting up of its own prototype testing station.

The South Bank Exhibition

No. VIII—(*Continued from page 780, June 15th*)

THE display on the first floor gallery of the Dome of Discovery helps to depict in some measure the nature of the universe. On this particular gallery the visitor is able to contemplate those nearer regions of the sky, the troposphere and ionosphere, together with the seemingly boundless regions of outer space.

Time

Access to the gallery is gained by the escalator, whence the narrative begins with a display of pieces for the accurate determination of time and place, one of the immediately practical uses of astronomy. There is here a reconstruction of the Greenwich time ball, which used to be dropped at one o'clock each day to enable ships in the Thames to regulate their chronometers. The development of other methods of timekeeping is illustrated by many exhibits of early chronometers and escapements. Amongst them is a fifteenth century wall alarm clock fitted with the bar foliot escapement, one of the earliest escapements devised; a later striking clock movement, by Fromanteel, London, of about 1675; and a half-second gridiron compensating pendulum dated 1840. Later came the Standard Sidereal clock, constructed by E. Dent and Co., to the specification of the Astronomer Royal, Sir G. B. Airy, between 1868 and 1872, and used at the observatory until 1920. It is stated to be one of the most precise mechanical clocks ever made. Also from the Royal Observatory is a phonic motor clock controlled by a quartz crystal, which has an error of only one second in three years. It is used for the control and emission of time signals transmitted from the Abinger Magnetic Station, Surrey.

Outer Space

Adjacent to this display are a number of demonstration models of different elements of the universe. The major planets are presented as they would appear from their satellites. There is a part map of the moon, constructed from present knowledge of its contours, craters and surface temperatures, and a photograph of the moon, loaned by the Lick Observatory, California. Other photographs, including the sun and the stars, have been loaned by the Astronomer Royal and the Royal Astronomical Society.

A demonstration model of particular interest is that made by the Sondes Place Research Institute of the solar system.

When first commissioned, it was decided that the most effective way of displaying the nine planets with their satellites would be by direct vision under ultra-violet light, the planets and satellites being coated with fluorescent paint, and the display stand and mechanism being completely blacked out. This would give the desired three-dimensional effect. The choice of a suitable scale was naturally the first problem.

In order to bring the whole solar system within reasonable viewing dimensions, at rational relative distance for all planets, the radial distances of the planets from the sun were first scaled down logarithmically and then reduced by a simple reduction factor to bring the maximum diameter of the orbits (Pluto), to 16ft. The diameters of the sun and planets were also logarithmically scaled down and further arbitrary reduction factors applied to all except the Earth, Mars, Mercury and Venus. The distances of the satellites from their planets were scaled empirically so that they should have sufficient clearance to pass each other and the satellites of neighbouring planets. From considerations of the different satellites, it was found that the variation in size would be so slight on this scale that it would not be apparent under ultra-violet light. Two sizes were therefore chosen as alternative standard sizes for all satellites.

The speeds of the planets around the sun were scaled up linearly, with certain slight adjustments to simplify the gear ratios, as were the revolutions of the planets on their own axes. The speeds of the satellites around the planets were also increased on a linear scale in the first instance, but it was soon found that the resulting speeds were too great and caused trouble.

As the ellipticity of planetary orbits is slight, the planets were arranged to follow concentric circles around the sun. It was not practicable to show their true inclinations to the ecliptic plane, but some were positioned above it and others below it. The orbits of the satellites were also made concentric. Direction of movement is as viewed from the North. Progressive or retrogressive movement of the satellites is shown as it occurs in fact.

Certain planets have special characteristics which had to be taken into account. For example, it is not known whether Pluto, the most distant planet, revolves on its own axis. It also has an elliptical orbit about the sun, and in the course of describing it rises and falls above and below the ecliptic plane. Pluto was accordingly made stationary on its own axis, but the latter two motions were successfully reproduced. Saturn's rings are shown by means of a transparent plastic collar fitted around its equator and dotted with fluorescent paint, which gives an appropriately hazy effect as the planet revolves. In the case of Mars, the orbital speed of its innermost satellite, Phobos, is greater than the axial speed of the planet itself. This also produced "persistence of vision" when scaled up linearly, and it was therefore necessary to reduce considerably the axial speed of Mars.

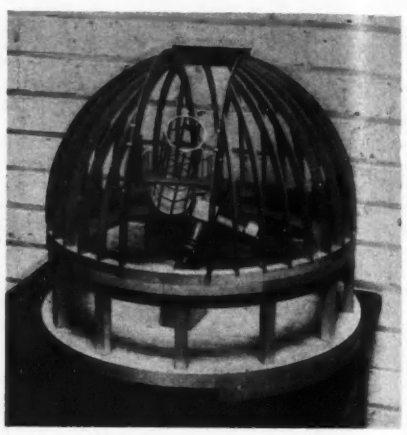
Mechanism and Construction

In general the mechanism can be regarded as a large nine-handed clock, the sun revolving in the centre and the planets with their satellites revolving on turrets at the ends of the hands or arms, the general arrangement being shown in our diagram.

The power for driving the mechanism is supplied by a 1½ h.p., 1440 r.p.m. electric motor, using a vee belt drive to a worm reduction gear, the output shaft of which is directly coupled to the axis of the sun, a ½in diameter shaft revolving at 27 r.p.m. The arms on their central turntables are driven by hollow shafts of seamless steel tube concentrically disposed around the axis shaft of the sun, this shaft providing the motive power for all the tubes through the main gear train. Lay shafts and idler gears are used to achieve the necessary reduction.

Keyed to the hollow main driving shafts are the central turntables, which are circular ribbed plates in cast aluminium. Bolted to these are the arms, each arm being formed of two beams of I-section light aluminium alloy, 3in by 1½in, set at an angle to each other and sheathed on the top surface with 16-gauge aluminium sheet. The outer ends of the arms carry, with three exceptions, the turret base castings, which support mild steel cylinders or turrets housing the drive mechanism for the axial rotation of the planets and the orbital rotation of their satellites. The three exceptions are Mercury, Venus and Jupiter, which are rotated by direct belt drive from grooves on the turntables of the planets above them. Each of the other six planets is rotated by bevel gears driving off the turntable through a shaft connected to a clockwork train of wheels and pinions in the turret. The ratios of these turret mechanisms have been selected to achieve the correct revolutions of the spheres. Although there are sixty-five gears in the six clock turrets, only seventeen different gears are used.

The axes of the planets Earth, Mars, Uranus and Neptune are all inclined to their orbits. This has been reproduced by mounting the clock gearing in their turrets at the required angles and fitting universal ball joints to the vertical drive shafts within the turrets. Furthermore, as the inclined planes



Model of 61 ft diameter Dome for 74 inch Telescope

of these planets must always face the viewing point, provision has been made for their turrets to turn through one revolution in the opposite direction to that travelled by their respective arms during one revolution.

The spheres of the sun and planets are made from copper or aluminium sheet in two halves brazed together. The satellites are of solid brass or steel.

The complete mechanism is mounted on a steel cradle fixed to an angle iron frame standing on channel members connected to the display stand, and arranged so that the ecliptic plane is at an angle of 45 deg. to the floor.

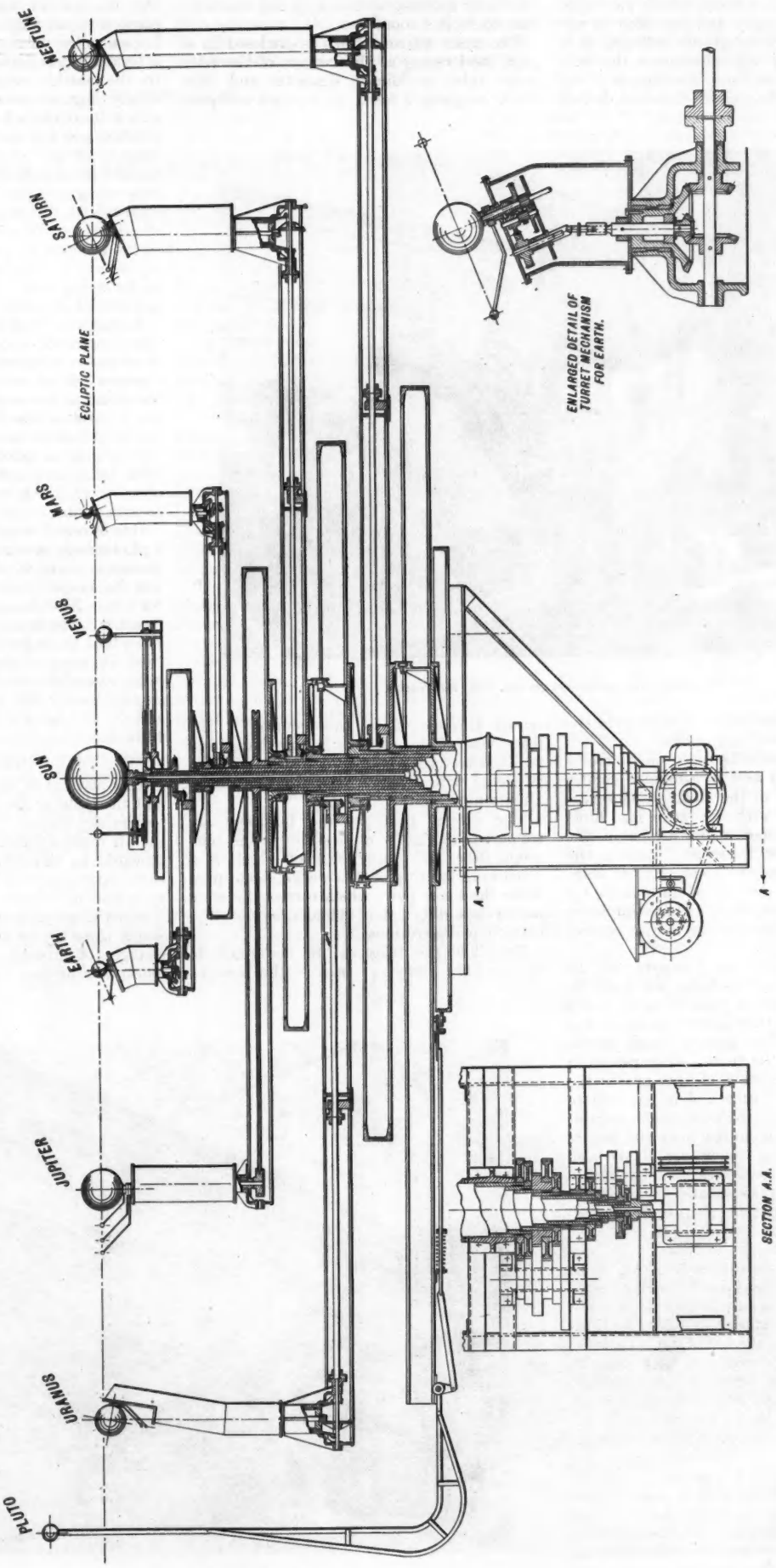
The galaxy of stars known as the Milky Way, of which the solar system forms but a single entity, and other nebulæ are depicted with the aid of new techniques in visual presentation.

In association with such a display telescopes have a natural place, and a replica of the new installation at St. Andrew's is shown, whilst on the ground floor is the 74in telescope now being completed for use in Australia.

74in Telescope

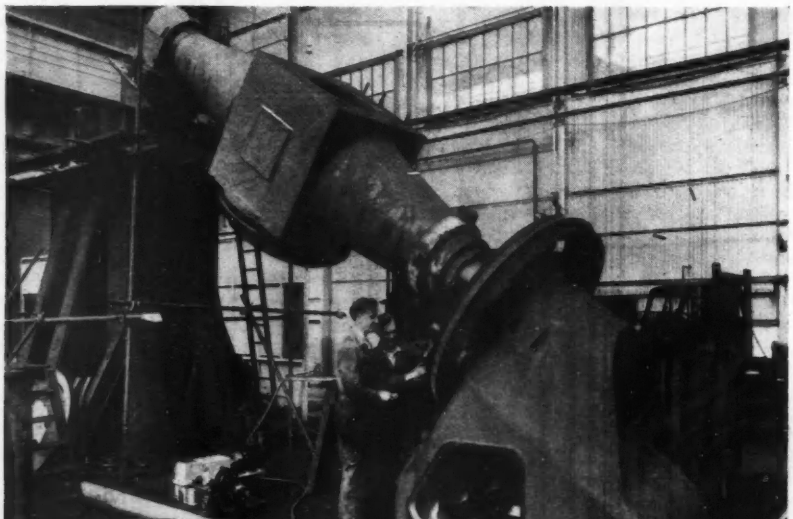
The 74in reflecting telescope, exhibited on the ground floor is being made by Sir Howard Grubb, Parsons and Co. for the Australian Commonwealth Observatory at Mount Stromlo, near Canberra. When the telescope

THE SOUTH BANK EXHIBITION



GENERAL ARRANGEMENT OF MECHANISED SOLAR SYSTEM DISPLAY

is installed in the observatory it will rank as equal with the 74in reflector which was made by the same company and has been in use at the Radcliffe Observatory, Pretoria, since 1948. At present this telescope is the only large one in the southern hemisphere; the Mount Stromlo reflector will therefore double the rate at which astronomers can survey the stars in the southern hemisphere.



POLAR AXIS ASSEMBLED IN ITS BEARINGS

The new instrument is based on Newton's reflecting principle and is generally similar to its counterpart in the Radcliffe Observatory. Experience with the latter has, however, suggested some modifications in the design of the new telescope. Among the important modifications is the use of thin-walled steel tubes, instead of duralumin, for the upper skeleton tube. Some improvements have also been made in the control arrangements.

Briefly, the telescope consists of an arrangement whereby starlight, which can be regarded as a beam of parallel rays, passes down the skeleton tube (shown in one of our illustrations) and falls upon the main mirror at the bottom of the tube. After reflection at the paraboloid surface of this mirror the light passes up the tube and is reflected to one side by a smaller Newtonian flat mirror, 20in in diameter, mounted near the top of the tube. Opposite this mirror at the side of the tube is a holder carrying a photographic plate or eyepiece, and there is provision for two different means of spectrographic examination.

As an alternative to the Newtonian focus arrangement it is possible to cause the light to be brought to a focus just behind the main mirror at the Cassegrain focus. To do this, a convex mirror is substituted for the Newtonian flat mirror at the top of the main tube. The light is thereby reflected back towards the base of the tube, where it passes through a hole in the main mirror. With this arrangement starlight can be fed into the slit of the spectrograph located at the bottom end of the tube.

A third optical system is provided, whereby the focus can be brought to a point known as the Coude focus, just outside the lower bearing of the polar axis. The Coude focus is, of course, fixed irrespective of the direction in which the telescope may be pointing and it is used to feed light through the slit of a very large spectrograph in a special temperature-controlled room.

The main mirror, which is enclosed in a solid steel casing at the bottom of the telescope tube, is 76in in diameter and 12in thick, weighing 2 tons. It was cast and processed throughout in this country. The front face of the glass is hollowed out and polished to form a paraboloid surface, which is coated with a very thin reflecting film of aluminium.

The optical parts of the telescope are supported as rigidly as possible in the telescope tube, the upper part of which is a framework built up of thin-walled steel tubes, while the lower part, which carries the main mirror, is a ribbed steel cylinder, as shown in one of our illustrations.

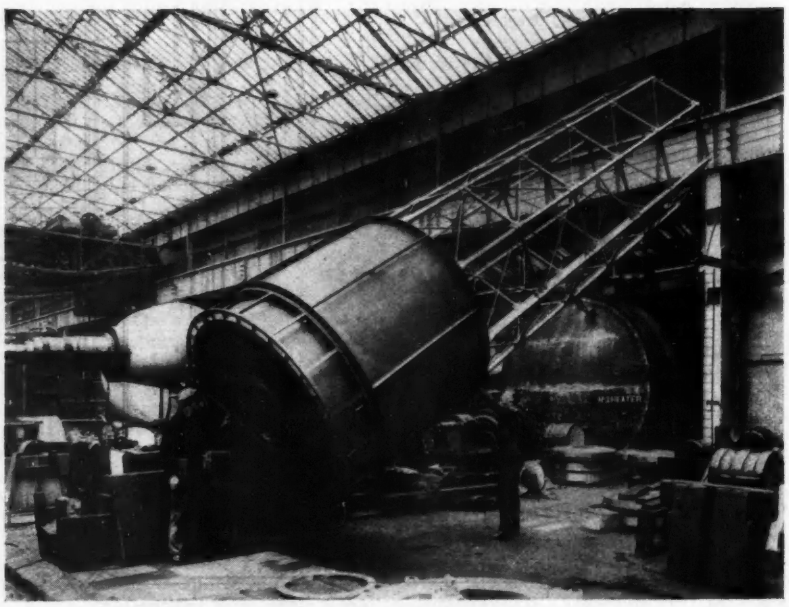
To allow the telescope to be aimed to receive light from any part of the heavens the tube is pivoted upon an axis known as the declination axis, which, in turn, is pivoted on an axis at right angles to it and known as the polar axis. When the telescope is installed it is set with its polar axis parallel to the earth's rotational axis, so that a steady angular movement about the polar axis will counteract the effect of the earth's rotation and will leave the telescope pointing steadily at any chosen star. The required angular motion about the polar axis has to be very accurately controlled and the drive is transmitted through an 8ft diameter worm wheel having 960 teeth. The drive is stated to be accurate to $\frac{1}{2}$ second of arc, which is equivalent to aiming the telescope exactly on a moving object the size of an orange at a distance of 20 miles.

Adjustment of all the motions can be made from a control desk which carries dials to show the orientation of the telescope. The observer is, of course, near the particular focus that is in use at the time, and there he has control of the fine motions of the telescope, whereby he can ensure that all is well during a photographic exposure. A loud speaker telephone system keeps the observer in touch with the operator at the control desk.

One of our illustrations is reproduced from a photograph of a wooden model of the 61ft diameter dome in which the 74in telescope will be housed; the observation platform for the Newtonian focus can be seen. Another illustration shows the polar axis assembled in its bearings at the works. The third illustration shows the telescope tube being assembled at the works. The tube is approximately 30ft long and 8ft in diameter and the weight of the moving parts is about 40 tons.

THE SKY

This account of outer space occupies over half the gallery, the rest of which is devoted to the sky theme. This theme deals with the air masses which envelop the earth and upwards to the ionosphere, where are the three main layers of ionised vapours existing at heights of between 70 miles and 250 miles. Various displays account for the process by which these layers are ionised, their diurnal changes of intensity and the effect of the ionosphere on radio wave propagation. For



TELESCOPE TUBE ASSEMBLED AT WORKS

the latter effect an animated wall demonstration with recorded commentary has been devised by Synchrophone, Ltd. This vertical display shows the manner in which radio waves become deflected, illustrates "skip" distance and other reception phenomena, and accounts for the short ranges associated with television. On another model is shown the effect of sunspots on the earth's magnetic field, resulting in periods of intense ionisation.

(To be continued)

The Fifth Centenary of Glasgow University

(Contributed)

GLASGOW University is this week celebrating officially the fifth centenary of its foundation. Actually it was on January 7, 1451, that Pope Nicholas V, at the request of James II, King of Scots, and on the application of William Turnbull, Bishop of Glasgow, issued a Bull of Foundation for a *Studium Generale* to be established in Glasgow.

To any Glasgow graduate—and, indeed, to all connected with the city—it is a little galling to hear, as in these days they often do, their *Alma Mater* classed among "the younger universities." St. Andrew's is somewhat older than Glasgow and Aberdeen somewhat younger. But even Edinburgh, the youngest of the four Scottish seats of learning, has been in unbroken existence for close on four hundred years. Admittedly, Oxford and Cambridge were founded before any of them, but it is still true that many of the individual colleges which make up the two great English universities cannot claim to be senior to, or as old as, their Scottish sisters.

Misunderstanding in this respect, so far as Glasgow is concerned, perhaps springs from the fact that any visitor to-day to the buildings crowning the noble height of Gilmorehill who inquires their age will be told that they date from 1870. But the age of a university is not to be measured by the age of its stones. The continuity of its activities in the promotion of learning and culture is the true criterion.

At the outset Glasgow University was poorly endowed. It had no home of its own and had to rely on the church for shelter. The first meeting of incorporation was held in 1451 in the Chapter House of the Black Friars. Later the members met in the Chapter House of Glasgow Cathedral. In the Crypt of that ancient building occasional lectures in Canon and Civil Law were given, but the only organised faculty was the Faculty of Arts—in which the instruction given was presumably entirely in the classical languages.

The use of the cathedral crypt as a meeting place continued until the Reformation. Subsequently the Faculty transferred its schools to a tenement in Rotten Row, where "teaching, lodging and a common table" were provided. The ruins of this building, which came to be called "the Auld Pedagogy," survived until the middle of the nineteenth century.

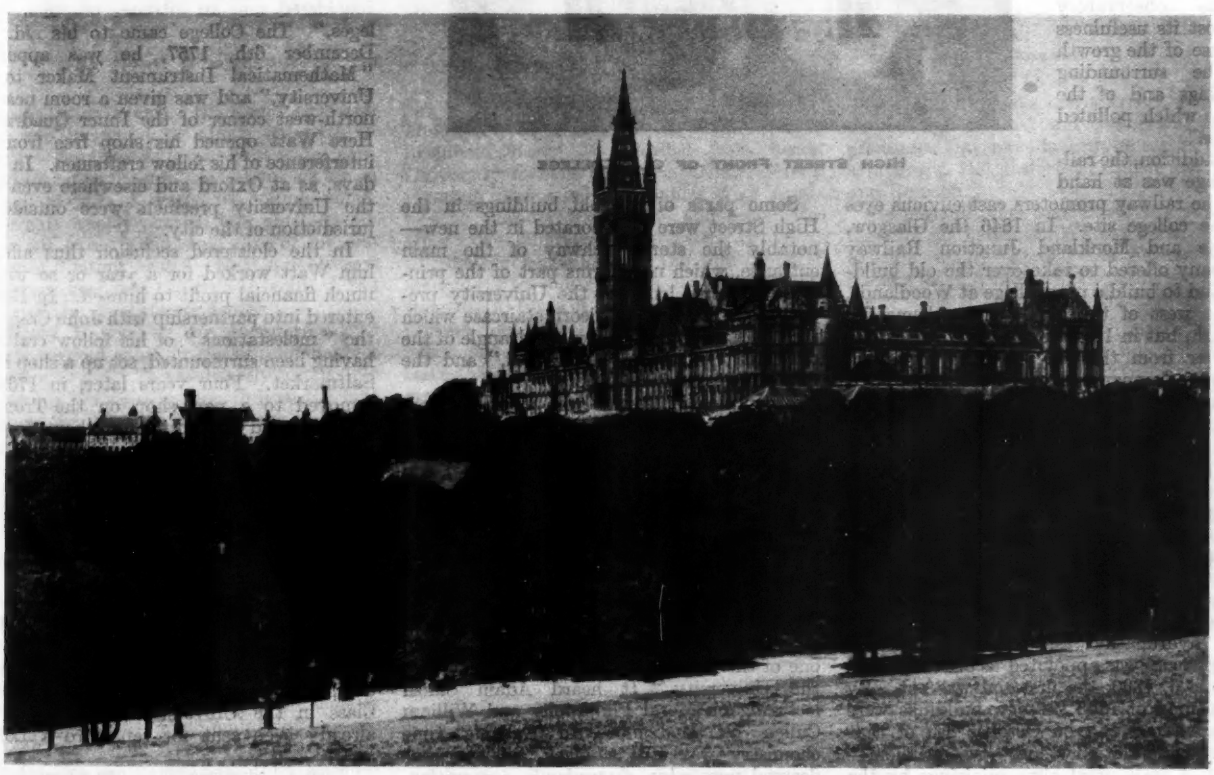
In 1460 the feeble life of the infant University was strengthened by a gift from James, first Lord Hamilton, of a tenement and four acres of land stretching from the High Street down to the Molendinar Burn. In 1467 Thomas Arthurlie gifted an adjoining tenement and croft, and about a hundred years later Mary, Queen of Scots, gave an additional thirteen acres to the site.

On the ground thus acquired the "old Colledge" was developed during the succeeding four centuries. The first buildings erected upon it consisted of one providing a hall for meetings and another hall for the schools and a library, a second building containing two rooms with a loft above, in which some chambers for teachers and students were arranged, a bell house and kitchen and a separate house, with a thatched roof, for the Principal.

Those early buildings lasted about two hundred years. In 1631 a public subscription was opened for the purpose of "building an commoun librarie within the Colledge of Glasgow" and of "utherways inlarging the fabrick of the said colledge to the publick and privat use of the students." The subscription was liberally supported by the nobility and gentry and by certain burghs, the clergy, members of the University, merchants and others. It is on record that Charles I in 1633 undertook to subscribe "Two Hundred Pounds Sterlin" to the fund, but that he overlooked payment. The sum was duly paid in 1654 by the Lord Protector, Cromwell.

Building operations were begun in 1632, but the outbreak of the Civil War interrupted them for a time. They were vigorously renewed when peace was restored, and by about 1661 the College possessed, as a contemporary visitor described it, "a pretty stone building not inferior to Wadham and All Souls Colleges in Oxon." The buildings had a handsome frontage on the High Street and were grouped round an outer and an inner quadrangle paved with red sandstone. In addition to meeting halls, examination and classrooms, the buildings provided housing for the Principal and the two professors of Divinity and lodgings for students.

During the eighteenth century the buildings were considerably enlarged. Along one



THE GILMOREHILL BUILDINGS—1950

side a court was added to provide houses for twelve professors and in rear of the main structure a new library was built. In 1757 an observatory was erected to house some astronomical instruments bequeathed to the University by Alexander Macfarlane, a Jamaican merchant.

The early nineteenth century saw further additions. The rearmost end of the Inner Quadrangle was pulled down and in its place there was built the Hamilton Building at the expense of a bequest made by Mr. Robert Hamilton, a merchant of Canton. In 1804 the Hunterian Museum was erected in rear of the main buildings to house the collections bequeathed to the University by its former student and graduate, William Hunter, the eminent anatomist and scientist.

In the Papal Bull of 1451 Glasgow was described as a place in which "the air is mild, victuals are plentiful and great store of other things pertaining to the use of man is found." Even before the middle of the nineteenth century, however, the growing industrial development of the city was making it difficult for the university to continue its activities on its original site on the High Street. It was situated in a now densely populated district of the city, which left little room for expansion. Smoke and chemical fumes were playing havoc with the fabric of the buildings and in spite of continual repairs they were falling into decay. Even by 1830 the Macfarlane observatory had lost its usefulness because of the growth in the surrounding buildings and of the smoke which polluted the air.

In addition, the railway age was at hand and the railway promoters cast envious eyes on the college site. In 1846 the Glasgow, Airdrie and Monkland Junction Railway Company offered to take over the old buildings and to build a new college at Woodlands, to the west of the city. This scheme fell through, but in 1864 the university accepted an offer from the City of Glasgow Union Railway Company—later the Glasgow and South-Western Railway—to purchase the old college and its grounds. Possession was to be deferred until new accommodation had been provided for the University.

The site chosen for the new buildings was Gilmorehill, an eminence to the west of the city, at the foot of which flowed the River Kelvin, a tributary of the Clyde. The new site was occupied at that date by Gilmorehill House, erected at the beginning of the century as a private residence, but later used as a hydropathic establishment. George Gilbert Scott was appointed as architect, and on June 6, 1866, the first sod was cut. By the autumn of 1868 the new buildings were well advanced and on October 8th of that year the foundation stones—two of them—were laid amid great civic rejoicings by the Prince and Princess of Wales—the future King Edward VII and Queen Alexandra.

By the end of 1869 about two-thirds of the main buildings had been erected. It was, however, impossible to complete the work by July, 1870, the date fixed for the surrender of the old college to the railway company. The completion was postponed and temporary arrangements were made to enable the 1870–71 session to be opened at Gilmorehill. The Senate met for the last time at the old college on July 29, 1870, and on November 7th of that year the Duke of Montrose, as Chancellor of the University, performed the inaugural ceremony at Gilmorehill.

Initially the new buildings formed three sides of one large quadrangle. Subsequently the enclosed space was divided into two quadrangles by the erection of two halls—the Bute and Randolf—with cloisters beneath.

HIGH STREET FRONT OF OLD COLLEGE

Some parts of the old buildings in the High Street were incorporated in the new—notably the stone archway of the main entrance, which now forms part of the principal entrance lodge to the University precincts, the Lion and Unicorn staircase which used to lead from the outer quadrangle of the old buildings to the "Fore-Hall," and the panelling of the Court Room.

Among the professors who migrated from the High Street to Gilmorehill in 1870, two of especial interest to engineers were Sir William Thomson (Lord Kelvin to be) and and W. J. Macquorn Rankine. These two men in their own departments—Natural Philosophy and Civil Engineering—brought with them the memories and traditions of a proud past.

The eighteenth century was a period of temporary decadence at Oxford and Cambridge. By contrast at Glasgow it covered one of the brightest periods in the history of the University. It heard Adam Smith lecturing on Moral Philosophy and William Cullen on Medicine. In Cullen's time chemistry was still a black art and was deemed unworthy of academic recognition. Nevertheless, Cullen, sifting the seed from the chaff, began to lecture on the subject as an adjunct to medicine. In time there came from Belfast a young student, Joseph Black, who, selecting medicine as his profession, attended Cullen's lectures on chemistry. Later, Black was appointed by Cullen to be his laboratory assistant. In 1750 Black went to Edinburgh University to complete his medical studies and in 1754 obtained his degree of Doctor of Medicine, his dissertation being his famous report in which he announced his discovery of "fixed air."

In 1756 Cullen was appointed Professor of Chemistry at Edinburgh and Black succeeded him at Glasgow as Professor of Medicine and Lecturer in Chemistry. Black occupied that chair until 1766, when he was appointed to succeed Cullen at Edinburgh. It was during the ten years of his professorship at Glasgow that Black carried out the momentous experiments which established the reality of specific and latent heats and evaluated them for water and steam.

In the very same year, 1756, in which Black took up his professorial duties at Glasgow, James Watt, then in his twenty-first year, returned to his native town of Greenock after his twelve months' sojourn in London. He had conceived the idea of setting up in business as a maker of mathematical instruments. To further that end he called upon Dr. Robert Dick, who had succeeded his father—of the same name—as Professor of Natural Philosophy at the college. Watt's visit to Dick coincided with the arrival of Alexander Macfarlane's collection of astronomical instruments from Jamaica. Some of the instruments had suffered by exposure to the sea air during the voyage. Dick asked Watt to stay in town to clean and repair them and for that purpose placed a room at his disposal within the college buildings. Watt gladly undertook the work and for it was paid £5.

In 1757 Watt decided to remove from Greenock to Glasgow, but his efforts to open a shop as a maker of mathematical instruments were, in Joseph Black's words, "molested by some of the corporations, who considered him an intruder on their privileges." The College came to his aid. On December 6th, 1757, he was appointed "Mathematical Instrument Maker to the University," and was given a room near the north-west corner of the Inner Quadrangle. Here Watt opened his shop free from the interference of his fellow craftsmen. In those days, as at Oxford and elsewhere even now, the University precincts were outside the jurisdiction of the city.

In the cloistered seclusion thus afforded him Watt worked for a year or so without much financial profit to himself. In 1759 he entered into partnership with John Craig and, the "molestations" of his fellow craftsmen having been surmounted, set up a shop in the Saltmarket. Four years later, in 1763, he removed to a new shop on the Trongate, where he sold "all sorts of mathematical and musical instruments with variety of toys and other goods."*

The business prospered, as is shown by the fact that several journeymen and apprentices were soon being employed. Watt presumably continued to be recognised as mathematical instrument maker to the University. The turning point of his career—and that of many others—came in 1763, when he was asked by Professor John Anderson to repair a model Newcomen steam engine belonging to the Natural Philosophy Class in the University. The model had already been sent for repair to a London

* From an advertisement in the *Glasgow Journal*, December 1, 1763. "Toys" were metal ornaments, not children's playthings.

instrument maker, but had been returned in an unsatisfactory condition. Watt took it in hand, quickly mastered its mode of action and restored it to proper order.

His interest in steam power was aroused. He soon realised that the Newcomen engine was very inefficient because the cylinder, cooled by the injection of cold water at the top of the stroke, condensed the steam admitted to it at the start of the next cycle. He made experiments which showed him that at every stroke the cylinder was using several times its own volume of steam. How was the cylinder to be kept hot while the steam in it was condensed? In May, 1765, the solution of the problem came to him suddenly. The cylinder was to be kept constantly hot by means of a steam jacket. At the end of the stroke the steam was to be allowed to rush into a separate vessel, in which a vacuum was maintained, and therein condensed.

Watt made an experiment. Into a glass vessel containing some water at room temperature he passed steam until the water reached boiling point. He found that the water had increased by about one-sixth in volume. The deduction was that water converted into steam could heat about six times its own weight of water to boiling point. This result greatly puzzled him until Joseph Black, his close friend, told him of his discovery of "latent heat." Watt quickly saw that latent heat was the crucial factor in the theory of the separate condenser.

Glasgow University can therefore justly claim a twofold share in the development of the steam engine. It was directly responsible for turning Watt's attention to it in the first instance—he might otherwise have remained all his life a maker of mathematical instruments. And through Black it laid the very corner stone of the science of thermodynamics.

Another figure flits across the scene. John Robison, three years Watt's junior, had just graduated at the University. He and Watt became close friends. Robison was a frequent visitor to Watt's shop and by discussion and otherwise did much to help and encourage him in his studies of the steam engine. He appears to have been the first person to whom Watt showed the hastily constructed model—made mainly of soldered tinplate—by which Watt in 1765 demonstrated to his own satisfaction the soundness of his ideas regarding a separate condenser. This model is now preserved in the Science Museum, South Kensington. In 1766 Robison succeeded Black at Glasgow and in 1796 at Edinburgh. It is mainly through him as Black's biographer that to-day we possess our knowledge of Black's work and achievements.*

In an atmosphere so intimately connected with the early days of the steam engine it is not surprising that in the years to come Glasgow University was to make further great contributions to its scientific study. It was at the Old College in the High Street that William Thomson, then Professor of Natural Philosophy, studied the almost forgotten writings of Sadi Carnot and gave them a new life which blossomed into the science of thermodynamics. There, too, laboured Macquorn Rankine, who in 1855 had succeeded Lewis Gordon, the first Professor of Engineering, appointed by Queen Victoria in 1840.† Rankine did not long survive the removal to Gilmorehill. He died in 1872 at the early age of fifty-two. His successor in the Chair of Engineering was James Thomson, Sir William's elder brother, and when Thomson retired in 1889 his former pupil, Archibald Barr, was recalled from Leeds University to take his place. Under Barr's vigorous incumbency the James Watt Engineering Laboratories were added to the University buildings. They were extended in 1920 to accommodate the multitude of students who, both during Barr's own lifetime and in those of his successors, Professors Cormac and Gilbert Cook, have come from every part of the world to the ancient city to learn the art and science of engineering in all its branches.

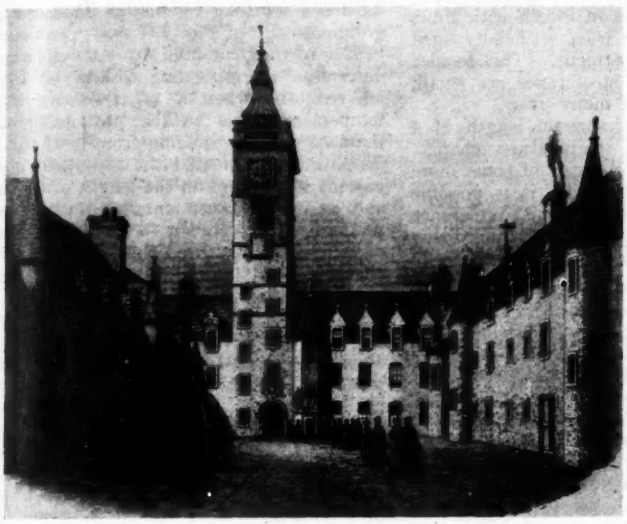
To one student at the University nearly fifty years ago the buildings at Gilmorehill already seemed old. Was it because embodied in them were a few stones brought reverently from the Old College in the High Street? Or was it because to him the University was something older than its buildings, something more enduring, something which transcended its material habitation, something which in spite of all outward changes continued to perpetuate the brooding wisdom of half a thousand years?

Vividly he still remembers a fleeting glimpse of the ancient Kelvin, near the end of his years, moving with faltering steps through the cloisters. It was not his fortune to sit at Kelvin's feet, but he is glad and proud to remember that such knowledge of natural philosophy as he possesses was acquired from Andrew Gray, Kelvin's pupil and immediate successor.

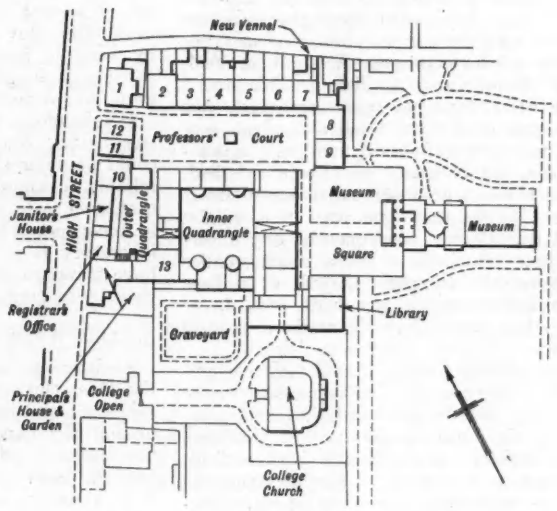
Gladly, too, does he recall his venerable professor of chemistry, John Ferguson. It was said of Ferguson that he could have occupied with distinction any Chair in the University except that which he held. But whatever Ferguson's merit as an instructor of youthful medical and engineering undergraduates may have lacked, he certainly was a link with the past, with Cullen and Black and Robison.

Respectfully he remembers his old professor of mathematics, William Jack. A man of wide culture—at one time he had been a partner in Macmillan's, the publishers, and, for a space editor of the *Glasgow Herald*—Jack with his long silvery curls, his whiskers, and his clean-shaven upper lip, might have come straight from the Old College in the High Street. Benign in appearance and gentle in manner, he ruled his class with a tranquil spirit in the presence of which the most riotous student was dumb. In one of his students at least he succeeded in converting an initial strong distaste for mathematics into a love for it which still abides.

But of all his fond memories he recalls with greatest gratitude the years which he spent under Archibald Barr. Barr was a great and inspiring teacher, in whom respect for science was tempered by a rare and exceptional bent towards its practical applications. That dual characteristic was convincingly demonstrated when in conjunction with his former colleague at Leeds, Professor Stroud, he invented his range finder and then, because no one in the country could be found to make it, set up a factory to do the



THE INNER QUADRANGLE OF THE OLD COLLEGE



PLAN OF THE OLD COLLEGE

* The American historian, Francis Parkman, writing in 1851, recorded that "the late celebrated John Robison, Professor of Natural Philosophy in the University of Edinburgh," had, as a young man, been a midshipman in the British Navy and that he was in Wolfe's boat on the night of September 12, 1759, as the British force rowed down the St. Lawrence to attack Quebec. In after life Robison told his son, Sir John Robison, that during the descent of the river Wolfe recited to those in his boat Gray's recently published "Elegy in a Country Churchyard," and at its conclusion said: "Gentlemen, I would rather have written those lines than take Quebec tomorrow." This anecdote is to-day commonly held to be apochryphal. But if Robison's testimony is accepted, the only point which we may doubt is whether Wolfe included in his recital the famous—and ominous— line: "The paths of glory lead but to the grave."

† It has been claimed that Gordon was the first professor of engineering at any university. Trinity College, Dublin, may perhaps be desirous of making a rival claim.

delicate work himself. The business prospered and, greatly enlarged in the scope of its products, still flourishes under the control of some at least who once were Barr's pupils at the University.

Right throughout the planning and organisation of the James Watt Engineering Laboratories and in the instructional courses given therein Barr infused his spirit as a scientific and practical engineer. To-day many of his one-time students in many parts of the world have reason to be grateful to him for the success which attended his labours to implant his own spirit in them.

In Barr there resided unmistakably the traditions of his predecessors. James Thomson and Macquorn Rankine had left their imprint upon him and beyond them it was not difficult to trace his inheritance from James Watt himself.

Of that inheritance one of his students fondly and humbly feels to-day that he partakes of a share. Such is the value of tradition at an ancient university.

Standardisation of Steel Surveying Tapes*

By J. S. CLARK, A.R.C.S., B.Sc., D.I.C., and L. O. C. JOHNSON

Introduction

SINCE about 1885 metal tapes or wires have been used almost exclusively for accurate base measurements in geodetic and other surveys of high precision. The use of metal tapes or wires suspended freely in catenary was suggested by E. Jäderin[1] and it soon superseded the earlier methods of base measurement, in which various types of rods or bars were used. Until about 1905, when Benoît and Guillaume[2] introduced invar wires, tapes of steel were used, but since that date invar tapes and wires have been more generally used, not only in standardising laboratories, but also in the field. The coefficient of linear expansion of invar is usually less than one part in a million per 1 deg. Cent.; consequently, any uncertainty in temperature has a much smaller effect on the computed length of a base when measurements are made with invar tapes than when they are made with steel tapes.

The greatest practical difficulty encountered in the use of steel tapes for precise base-line measurements is that of determining the true temperature of the steel when making measurements in the field, particularly in sunlight. The air temperature, as indicated by mercury in glass thermometers in the neighbourhood of the tape differs appreciably from the true temperature of the tape, except possibly during very cloudy sky conditions or at night time. The coefficient of linear expansion of steel is of the order of eleven parts in a million per 1 deg. Cent., and in ordinary field conditions the true mean temperature of a steel tape may differ from the mean temperature indicated by mercury thermometers in air near the tape by several degrees. Hence errors considerably exceeding one part in 100,000 may arise in the field through the uncertainty in the value of the temperature correction applied. Even under laboratory conditions, as at the N.P.L., it has been found impracticable to standardise a steel tape to an accuracy much better than a few parts in a million when its average temperature is assumed to be that of a number of mercury thermometers placed with their bulbs near the tape.

Steel tapes, however, apart from difficulties arising from the high thermal coefficient of expansion, are really more reliable than invar tapes. Metal tapes, whether of invar or of steel, are normally coiled on drums when not in use. When unwound from the drum a good steel tape will lie quite flat when resting on a flat surface and if it is damaged at any time the resulting kink or bend is immediately noticeable. On the other hand, invar tape, even when newly received from the manufacturer, is more or less irregular so that a small kink or bend caused by damage in use is likely to pass unnoticed and the tape may be used after damage, giving erroneous results. Steel tapes are manufactured free from kinks and are less liable than invar to damage in the field. Furthermore, invar tapes are subject to secular changes in length with time, even after they have been artificially aged by suitable heat treatment. The secular changes in length of steel tapes are small, even over a period of many years.

If, therefore, the change in length of a steel tape, due to temperature change, could be determined in terms of some more reliably measurable property, it is possible that steel tapes would be used in preference to invar ones in the field. In a standardising laboratory it is certainly an advantage to have standard tapes not subject to secular changes in length.

Earlier Work with Wheatstone Bridge

As long ago as 1891 G. A. Campbell, of the Massachusetts Institute of Technology, suggested and discussed a method of determining the expansion of a steel tape by measurement of its electrical resistance, but the method does not appear to have been actively pursued, possibly because of the subsequent introduction of invar surveying tapes and wires.

In 1923–24 investigations were initiated at the N.P.L. by S. W. Attwell, to see if it was possible to standardise and use steel surveying tapes by reference to their electrical resistances instead of in terms of their estimated mean temperatures. He used 24m and 100ft steel tapes and determined their resistances by means of a Wheatstone bridge. The circuit is shown in Fig. 1; it involved the use of a return lead of copper wire of known resistance A to connect the remote end of the tape to the variable resistance arm of the bridge. The battery lead also had to extend to the remote end of the tape and a short length of copper wire of known resistance D connected the near end of the tape to complete the bridge circuit. The actual connections to the ends of the tape were made by means of short lengths of copper wire of negligible resistance dipping into small cups C_1 and C_2 containing mercury. When the bridge was balanced the resistance of the tape between the points of contact a and b of the dipping wires was given by $(R_V+A)\ S/R-D$, where S was a standard 1 ohm resistance, R was a constant resistance of 1000 ohms and the variable resistance R_V was read on five dials, ranging up to 10,000 ohms. The measured resistance of the tape was the resistance between the points of contact a and b, which slightly exceeded the resistance between the fiducial marks c and d, defining the length of the tape. There was no objection to this because the dipping wires were permanently attached to the tape at a and b, and the length of the tape between c and d was standardised in relation to a suitable value of the resistance between a and b. Experiments were made with four steel tapes, all of cross-section 0·125×0·015 in (3·2mm×0·38mm). The thermal coefficient of linear expansion of the steel was known to be about $10{\cdot}8\times10^{-6}$ per 1 deg. Cent, and the thermal coefficient of resistance about 0·0033 per 1 deg. Cent. The resistance of each tape, of the order of 4 ohms, was measured to the nearest 0·0001 ohm, the tape being suspended in the usual way in single catenary under the standard tension T of 10kg weight, as indicated diagrammatically in Fig. 1.

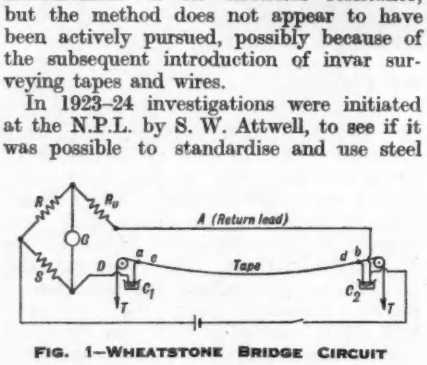


FIG. 1—WHEATSTONE BRIDGE CIRCUIT

The method adopted by Attwell was to determine corresponding values of length and resistance when the tapes were at various temperatures due to the passage through them of currents ranging from 0·2A to 5A. These currents heated the tape, and observations were made on the length of the tape and on its resistance simultaneously. By a preliminary experiment it was found that a current of 5A increased the length of a 24m tape by about 8·7mm, which indicated a rise in temperature of about 33 deg. Cent. The initial temperature being 17 deg. Cent., the current of 5A therefore heated it up to about 50 deg. Cent. Observations were made at temperatures below 17 deg. Cent. by suspending the tape in the 50m tank used normally for determining the thermal coefficient of linear expansion of surveying tapes and wires, the tape being surrounded by air cooled by iced water in the lower part of the tank.

Attwell obtained the results given in Table I for the rate of change in length with electrical resistance of the four steel tapes. In this table, $L_{3\cdot7}$ is the length of the tape No. 22 when its resistance is 3·7 ohms and a similar notation applies to the other three tapes.

TABLE I

Tape No.	Length of tape in mm when resistance is R ohms
22 (24m) ...	$L_{3\cdot7}+19{\cdot}564(R-3{\cdot}7)-0{\cdot}14(R-3{\cdot}7)^2$
23 (24m) ...	$L_{3\cdot7}+19{\cdot}758(R-3{\cdot}7)$
24 (100ft) ...	$L_{4\cdot8}+21{\cdot}633(R-4{\cdot}8)-0{\cdot}489(R-4{\cdot}8)^2$
25 (100ft) ...	$L_{4\cdot7}+20{\cdot}273(R-4{\cdot}7)-0{\cdot}245(R-4{\cdot}7)^2$

The absolute values of the lengths of the two 24m tapes were determined from time to time over a period of two years, covering a temperature range 14·4 deg. Cent. to 22·4 deg. Cent. They were compared directly with 24m standard invar tapes and with bench marks on the 50m comparator controlled by 24m invar sag wires.[3] The results, which were constant to within ±1 part in a million, are given in Table II, together with the corresponding results for the 100ft tapes, which were not determined until October, 1930.

Steel tapes so standardised in terms of their electrical resistance do not appear to have been used in the field until after 1938.

Pre-War Work with Kelvin Double Bridge

In 1938 the N.P.L. standardised a number of steel tapes in terms of their electrical resistance for the Australian Army Survey

* Communicated by the National Physical Laboratory.

TABLE II

Tape No.	Length when resistance is R ohms	Date
22	24m − 0·152mm + [19·564(R − 3·7) − 0·14(R − 3·7)²]mm	1923–24
23	24m + 0·450mm + 19·758(R − 3·7)mm	1923–24
24	100ft − 1·594mm + [21·633(R − 4·8) − 0·489(R − 4·8)²]mm	October, 1930
25	100ft − 0·675mm + [20·273(R − 4·7) − 0·245(R − 4·7)²]mm	October, 1930

Corps. As in the earlier measurements, a bridge method was employed but a duplicate steel tape was used in place of the copper return lead (A in Fig. 1). The tapes were used in pairs, and the resistance of a pair of tapes was measured so as to enable corrections for changes in their mean lengths due to changes of temperature to be made on the basis of the corresponding changes in their resistance. The two tapes of a pair were connected together electrically at one end by means of a short, flexible lead of resistance 0·005 ohm and at the other end each tape was connected to the bridge by means of a flexible lead of resistance 0·1 ohm. The bridge was used to measure the combined series resistance of the two tapes together with the 0·005 ohm lead, allowance for the other two flexible leads being incorporated in two of the bridge coils. Standardisation to an accuracy of one part in a million was successfully carried out at the laboratory and the only difficulty foreseen in using the tapes in the field was the possibility, even in a light cross wind, of the two tapes coming into contact and short circuiting.

Two pairs of these tapes were used by the Australian Army Survey Corps in the establishment of field standard bases with an accuracy within one part in a million and without much trouble from cross winds.[4] The bridge used in the field was that used at the laboratory for standardising the tapes. It was a modification of a Kelvin double bridge and consisted of four 100 ohm coils forming two pairs of proportional arms, together with a decade resistance adjustable between 5 and 15 ohms in steps of 0·001 ohm. A 10 ohm standard resistance was contained in the instrument to enable the accuracy of the bridge to be verified at the 10 ohm setting. The instrument also contained a suitably robust galvanometer of sensitivity 0·5μA per division, the whole forming a compact and reasonably portable unit.

No further developments occurred until after the war, when it was decided to establish at the N.P.L. a set of standard steel tapes measured in terms of their electrical resistance, using a potentiometer in place of a bridge to determine the resistance.

Post-War Work with Potentiometer

The tapes used by Attwell in 1923–24, namely, two 24m tapes Nos. 22 and 23 and two 100ft tapes, Nos. 24 and 25, were again used. The mercury cups then employed were discarded and the ends of the tapes were altered in accordance with Fig. 2, which shows details of the new terminal

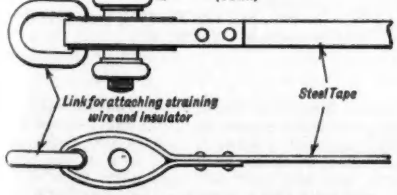


FIG. 2—TERMINALS FOR STEEL TAPES

fittings situated about 30cm beyond the graduation lines. As a result of these alterations, the overall lengths of the tapes have been shortened and, in consequence, their resistances have been reduced by about 5 parts in 1000. The subdivisions of the original terminal scales defining the lengths of the tapes were, in some cases, in error by as much as 0·02mm. In view of this, the scales were cleaned off and new ones, each 10mm long, were ruled on the tapes. The graduation lines of these new scales are spaced accurately to within 0·005mm and are so placed that the mean length† of each tape has not been altered by more than 0·01mm.

To avoid the possible errors arising from changes in temperature and therefore in resistance of the return lead A and of the short connecting lead D (Fig. 1), which may occur in the Wheatstone bridge circuit, it was decided to use a potentiometer method to determine the resistance of the tapes.

The essentials of the potentiometer and associated circuits used are shown in Fig. 3,

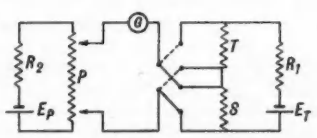


FIG. 3—POTENTIOMETER CIRCUIT

in which the resistance of the tape is represented by T, and S is a standard resistance connected in series with the tape, a 2V cell E_T and a current limiting resistance R_1. The potentiometer P is in series with the 2V cell E_P and another current limiting resistance R_2.

If the potential drop in the tape T is balanced across a potentiometer resistance P_T and that in the standard resistance S is balanced across a potentiometer resistance P_S, then the resistance of the tape T is $S \cdot P_T/P_S$.

To facilitate connecting a tape, supported in single or multiple catenary on insulated rollers, to the potentiometer, &c., four busbars of No. 16 gauge (1·6mm diameter)

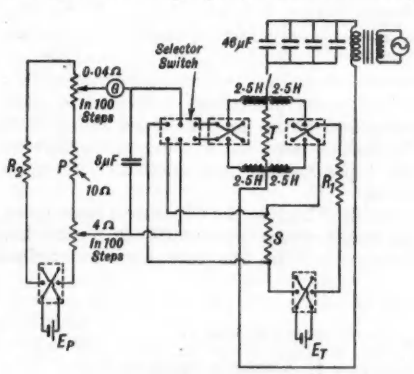


FIG. 4—COMPLETE CIRCUIT

copper wire were fixed permanently on insulators along the wall forming the comparator,[5] parallel to the bench and about 60cm above it. These busbars bear copper terminals positioned conveniently to connect them to the terminals of the tape. Referring to these busbars as Nos. 1, 2, 3 and 4, the ends of Nos. 1 and 3 towards the west end of the comparator were connected to an a.c. generator supplying current when required to heat the tape and those towards the east end of the comparator were connected (each through a 2·5H choke) to the potentiometer. The ends of Nos. 2 and 4 towards the east end of the comparator were connected (each through a 2·5H choke) to the circuit containing R_1, E_T and S (Fig. 3). The small residual a.c. which might conceivably pass the chokes was by-passed through a condenser of 8μF capacity across the potentiometer terminals (Fig. 4).

The potentiometer has a range from 10 ohms to 14 ohms, in steps of 0·0004 ohm. The galvanometer is of such sensitivity that balance points can be determined to ±0·0004 ohm, corresponding with about one part in 10 million in length of tape.

The standard resistance S is nominally 4 ohms, and its true value at any temperature between 10 deg. Cent. and 30 deg. Cent. was determined by the Electricity Division of the N.P.L.

In order to eliminate the effects of possible thermo-e.m.f., due to temperature differences in the circuits, a linked pair of double-pole two-way switches was provided for simultaneously reversing both batteries. The effect was small and was subsequently shown (by providing another linked pair of switches between the tape terminals and the potentiometer to reverse the tape connections) to be due chiefly to temperature differences at the two ends of the tape.

During measurement, each tape was supported in multiple catenary on rollers attached to the front edge of the measuring bench.[6] Attention therefore had to be given to the insulation of the tape from the rollers and from the invar insets bearing the bench marks, which are cemented into the Portland stone blocks forming part of the measuring bench. Although the insulation of the bench itself was such that leakage to the uninsulated rollers had scarcely measurable effect, as a precaution the tape was fully insulated from the rollers and from the invar insets by strips of mica.

The 2kc/s generator was capable of delivering up to 5A at 80V. As indicated in Fig. 4, the output of the generator was delivered to the tape through a 2 : 1 step-down transformer and a condenser of about 46μF, connections being made via two of the four busbars (1 and 3) referred to above. The d.c. connections to the tape were made via the busbars 2 and 4.

The effect of variations in the current-limiting resistance R_1 was investigated. The resistance of the 100ft tape, No. 25, when set up in the normal manner, under a tension of 10kg weight was measured (*a*) with no heating current in the tape and (*b*) with heating current 3·2A. With no heating current flowing, the resistance R_1 was varied between 633Ω and 753Ω to cover a range of potentiometer readings from about 10·01Ω to about 13·85Ω and, with 3·2A flowing, R_1 was varied between 673Ω and 753Ω to cover a similar range. The largest deviation from the mean value of tape resistance with 3·2A heating current flowing was 0·001Ω, corresponding with less than one part in a million on length of tape. When no heating current was flowing (as is normally the case when the tape is being used at ambient temperatures) the maximum deviation from the mean was 0·0003Ω, corresponding with one part in 4 millions on length of tape.

The relationship between the length and the resistance for each tape was determined by measuring simultaneously the distance between the fiducial graduations and the resistance of the whole length of the tape (*a*) at normal air temperature (about 20 deg. Cent.), (*b*) when sufficient a.c. was applied to raise the temperature of the tape about 12 deg. Cent. above ambient temperature, and (*c*) when the temperature was raised to about 25 deg. Cent. above ambient temperature. Measurements were repeated

† The "mean length" of the tape is the mean of the 11 nominally equal distances 0/0, 1/1 ... 10/10 between corresponding graduations of the terminal scales.

when the ambient temperature was about 15 deg. Cent. In this way the following relationships (Table III) were found to hold good over the temperature range 15 deg. Cent. to 45 deg. Cent.

TABLE III

Tape No.	Length of tape in mm when resistance is R ohms
22 (24m) ...	$L_{3\cdot7}+19\cdot607(R-3\cdot7)$
23 (24m) ...	$L_{3\cdot7}+19\cdot960(R-3\cdot7)-0\cdot622(R-3\cdot7)^2$
24 (100ft) ...	$L_{4\cdot8}+21\cdot602(R-4\cdot8)-0\cdot375(R-4\cdot8)^2$
25 (100ft) ...	$L_{4\cdot7}+20\cdot445(R-4\cdot7)-0\cdot350(R-4\cdot7)^2$

Seventeen simultaneous observations of length and resistance were made on each of the 24m tapes, the maximum residual being 0·023mm and the mean residual being 0·008mm, corresponding with one part in 3 millions in length of tape. Forty-two observations were made on the two 100ft tapes, the maximum residual being 0·022mm and the mean residual 0·007mm, corresponding with one part in 4 millions in length of tape.

The following table, which has been calculated from Table III and from Table I (the corresponding results obtained in 1923), gives the computed increase in length when the resistance increases by 0·15 ohm from the resistance at 20 deg. Cent., corresponding to a temperature rise of about 10 deg. Cent.

TABLE IV

Tape No.	Increase in length per 0·15 ohm increase in resistance	
	Present values	1923 values
22 (24m)	2·941mm	2·932mm
23 (24m)	2·980	2·964
24 (100ft)	3·232	3·234
25 (100ft)	3·059	3·036

It has already been explained that the overall lengths of the tapes (as distinct from their lengths between fiducial lines) have been shortened since 1923 and their resistances have thereby been reduced by about five parts in 1000. The present values of the increase in length in millimetres per $0\cdot15\Omega$ increase in resistance should therefore exceed the 1923 values by about five parts in 1000. When this is allowed for, the values in Table IV agree within $\pm0\cdot015$mm, the equivalent of one part in 2 millions on length.

Results of Post-War Standardisations

The tapes were standardised at ambient temperature in the usual manner[3] in terms of the N.P.L. reference standard bar No. 3060, which is of invar and which provides standardised lengths of 4m and 12ft 6in. The results are given in Table V, which is derived from Table III by inserting the values of $L_{3\cdot7}$, &c., obtained by this standardisation.

Twelve determinations of each of the 24m tapes were made, the maximum residual being 0·016mm and the mean residual 0·006mm, corresponding with one part in 4 millions in length of tape. Eleven determinations of each of the 100ft tapes were made, the maximum residual being 0·016mm and the mean residual 0·007mm, also corresponding with one part in 4 millions in length of tape. Taking into account residuals of the same order of magnitude in the determination of the rate of change of length with resistance (Table III) it is considered that the accuracy of length determination at any temperature between 15 deg. Cent. and 45 deg. Cent., derived from the data given in Table V, can be depended upon to within one part in 2 millions. At ambient temperatures not differing much from 20 deg. Cent., the accuracy might be as high as one part in 4 millions.

Stability of Steel Tapes—Comparison with Pre-War Measurements

In view of the fact that the overall lengths of the tapes and therefore their resistances, were reduced in the process of fitting the terminals direct comparison with the earlier results is impossible. Only the repetition of the work over a period of years will show whether or not the steel tapes are stable as regards their length and electrical resistance. There is, however, indirect evidence that the standardised lengths of the tapes have not changed on the average by more than two parts in a million in twenty-five years. In Table VII the resistance of each tape at 20 deg. Cent. is given for the various dates when determinations of resistance were made.

TABLE VI—*Lengths of Tapes at 20 deg. Cent. (Departures from Nominal)*

Date	No. 22 24m	No. 23 24m	No. 24 100ft	No. 25 100ft
	mm	mm	mm	mm
December, 1921...	+1·60	+1·53	+1·25	+1·03
1923–1924 (mean)	+1·60	+1·56	—	—
July, 1926	+1·53	+1·49	—	—
November, 1930	+1·66	+1·63	+1·32	+1·05
Mean, 1921 to 1930	+1·60	+1·55	+1·28	+1·04
April, 1949	—	—	+1·25	+0·97
August, 1949	+1·50	+1·51	—	—
Apparent decrease in length	4 parts in a million	2 parts in a million	1 part in a million	2 parts in a million

TABLE VII—*Resistance in Ohms of Tape at 20 deg. Cent.*

Date	No. 22 24m	No. 23 24m	No. 24 100ft	No. 25 100ft
1923-1924 (mean)	3·7631	3·7304	—	—
November, 1930	—	—	4·8848	4·7332
April, 1949 ...	—	—	4·8655	4·7134
August, 1949 ...	3·7419	3·7079	—	—
Reduction in resistance	0·0212	0·0225	0·0193	0·0198

The mean percentage reduction in resistance is 0·58 in the 24m tapes and 0·41 in the 100ft tapes; this is quite consistent with the tapes having been shortened by about 13cm.

Table VI gives the departures from nominal length of the tapes at 20 deg. Cent. when standardised in 4m catenaries at various dates. The earlier results are likely to be subject to larger errors due to uncertainty in the true temperature of the tape than the more recent measurements, which were made after the thermal conditions in the corridor containing the mural comparator had been improved. The individual measurements giving rise to the 1921 and 1930 values did, in fact, show deviations from the values quoted in the table, amounting to two parts in a million, whereas all the individual values, based on temperature, which were obtained in the recent (post-war) measurements were within one part in a million of the mean values given in the table.

There is some evidence in Table VI of a mean secular decrease in length amounting to about two parts in a million in twenty-five years but it is by no means conclusive.

Conclusions

It is concluded that the length of a standard steel tape (24m or 100ft) can be established in terms of its electrical resistance without any knowledge of its temperature, to an accuracy of one part in 2 millions. This applies to any temperature between 15 deg. Cent. and 45 deg. Cent. and, assuming that all the error is due to temperature uncertainty, corresponds with an accuracy of 0·05 deg. Cent. in determination of temperature. It is probable that such steel tapes are stable to within the same order of accuracy over a period of five years but to confirm this it will be necessary to repeat the standardisations at intervals of not more than five years. The usual precautions must, of course, be taken to prevent corrosion of the steel or any other damage likely to change the electrical resistance of the tape.

Potentiometer measurements of the precision required for standardising steel tapes to this degree of accuracy under laboratory conditions obviously cannot be carried out in the field, but once the tapes have been standardised and their rates of change of length with resistance have been determined at the laboratory, they may be used in the field, preferably in pairs (the duplicate tape acting as the return lead), using the Kelvin bridge method of determining their resistance. In this way an accuracy of one part in a million in the establishment of a field standard base has been achieved.

TABLE V

Tape No.	Length when resistance is R ohms
22	$24\text{m}+0\cdot672\text{mm}+19\cdot607(R-3\cdot7)\text{mm}$
23	$24\text{m}+1\cdot346\text{mm}+[19\cdot960(R-3\cdot7)-0\cdot622(R-3\cdot7)^2]\text{mm}$
24	$100\text{ft}-0\cdot159\text{mm}+[21\cdot602(R-4\cdot8)-0\cdot375(R-4\cdot8)^2]\text{mm}$
25	$100\text{ft}+0\cdot702\text{mm}+[20\cdot445(R-4\cdot7)-0\cdot350(R-4\cdot7)^2]\text{mm}$

Acknowledgment

The work described above has been carried out as part of the research programme of the National Physical Laboratory and this paper is published by permission of the Director of the Laboratory.

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[4] L. Fitzgerald, Report on the Measurement of the Jondaryan and Somerton Base Lines, Australian Army Survey Corps, 1939.
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[6] THE ENGINEER, *loc. cit.* page 202.

LONG DISTANCE TELEPHONE TRAFFIC.—During the year ended March 31, 1951, the General Post Office handled a total of 250,000,000 trunk and toll calls. Of these, 54,000,000 were at the cheap night rate and 5,000,000 were night calls at the full rate. In 1939 the total of trunk and toll calls amounted to 112,000,000 and in 1941 this figure had increased by only 6,000,000. In the four following years, annual totals increased sharply and in 1945 there were 189,000,000 effective calls made. In 1946 the increase was less pronounced, at 193,000,000 calls, but since then the annual total has progressively mounted at an average rate of 11,500,000 calls.

British Electrical Power Convention

THE third British Electrical Power Convention was held in Brighton this week (June 18th–22nd), under the presidency of Sir Henry Self, Deputy Chairman (Administration) of the British Electricity Authority. At the opening meeting on Tuesday, June 19th, the convention was formally inaugurated when the delegates assembled in the Dome for a civic welcome by the Mayor of Brighton. After a short speech of thanks, Sir Henry Self delivered his Presidential Address, abstracts from which are reproduced herewith.

This is the third year of the convention on the basis established when its scope was expanded to include all parties in the electrical industry on an equal basis. Last year, we had an impressive presentation by Sir Vincent de Ferranti of the broad position as seen from the standpoint of the electrical manufacturers, and as a preliminary to papers mainly directed to discussion of developments in the art of generation of electricity, coupled with treatment of the economic conditions in the industry.

This year the main subject is the art of utilisation of electricity—the theme which Sir Vincent himself suggested as a fruitful field for a future convention. Following a paper and demonstration on the subject of "Electronics," to be presented this afternoon, we shall have two papers to-morrow on the uses and application of "Electricity as a National Asset." Later in the week we shall have "A Survey of the Refrigeration Industry" and a paper discussing electricity as a factor in social progress. As a curtain-raiser to this comprehensive survey of the field of "utilisation," it is appropriate that I should briefly attempt some broad assessment of the status of electricity supply within the national economy.

In 1947–48 the income of the supply industry was running at something over £184 million per annum; in the year 1950–51 it was of the order of £236 million, an increase of over 28 per cent. If we were allowed to develop our proper commercial approach towards improving the load factor we might considerably better that position, but that is a separate issue.

The gross national product of this country, as set out in the Economic Survey, 1951, is estimated to be roughly £13,000 million this year. That means that about 2 per cent of the total national product is represented by electricity supply. In fact, the true picture is very much better than this shows, since the electricity prices have altered very little since pre-war, whereas general price rises of considerable magnitude are reflected in the figures of national product.

Looking at the number of staff employed, we find that the present figure of 176,000 employees in the electricity supply industry compares with a total population in civil employment of some 22,145,000, i.e., something just over three-quarters of 1 per cent.

Again, in regard to this country's one vital natural product—coal—the Survey shows electricity consumption in 1950 standing at 32·9 million tons, out of a total home consumption of 201·7 million tons, i.e., 16·3 per cent of total home consumption, as compared with 30·2 per cent for direct use by domestic, commercial and industrial small consumers, and 18 per cent for direct use by large engineering works and other industry. Consumption of coal by the electrical industry has already increased substantially as the plant development programme gets into its stride, but it is well to remember here that this mounting figure carries with it two marked advantages. First, that as each new plant comes into commission the higher efficiency results in more power from a given quantity of coal consumed; secondly, that the quality of coal consumed at generating stations is in general appreciably below that needed for other purposes. Nor can the "amenity" aspect be entirely overlooked. The old tag about there being no smoke without fire may be true enough, but here we have the generating stations burning over 16 per cent of the nation's coal; but, as Sir Vincent de Ferranti reminded us last year, producing only 0·4 per cent of the smoke emitted into the atmosphere every year!

Turning to the capital picture: there is at present well over £1000 million of capital invested in the supply industry. In the year 1948–49 our capital expenditure was £95 million, in 1949–50 we spent over £114 million, and last year we probably spent some £127 million. Even if we take capital expenditure at its present rate, therefore, ignoring the steady increase which is inevitable over the next few years, and relate it to the national capital investment expenditure per annum shown in the 1951 Economic Survey as roughly £2100 million, we find that the supply industry, whilst taking roughly 6 per cent of the country's capital resources, produces 2 per cent (and more on a true price comparison) of the national product, with some three-quarters of 1 per cent of the labour force available.

Thus we can well claim that the economies in the use of manpower and coal (the two most critical national assets) made possible by the production of electrical power, have contributed to the fullest possible extent to the overall national economy, whilst helping industrial productivity in general to achieve the increase of 30 per cent shown since 1947.

It is not surprising, therefore, that I should stress and re-stress the case for an approved allocation of capital expenditure adequate to enable us to erect all the plant we can get, compatibly with the legitimate needs of the rearmament programme and the exports programme; but home power production should have the first claim, as a prior essential both for the rearmament programme itself and also for the industrial production of export goods to pay for our food and raw materials.

You will all no doubt be familiar enough with the course of development of our plant expansion programme. Despite many setbacks and disappointments, new plant is now being installed at an annual rate considerably higher than any previously achieved. Over the five years since the production of heavy plant got under way again at the end of the war something over 3,000,000kW (sent out) of output capacity have been added; we are installing new plant now at an annual rate of something over 1,000,000kW (sent out), and yet we still have a plant shortage equivalent to a maximum of some 15 per cent at winter peak-load periods. To bridge that gap we hold the view, as you know, that the annual commissioning figure must be raised to some 1,600,000kW to 1,800,000kW (sent out), and it is here that we come acutely up against the argument that an annual programme of such a size takes more than can be allowed in the present state of the national resources.

Analysis of Electricity Consumption

Let us consider for a moment, however, the make-up of the demand which is the cause of our problem, and the general pattern of its growth. Analysis of the figures of consumption for the year 1949–50 shows that industry took over 50 per cent, commerce, traction and public lighting 16·5 per cent, domestic 32·5 per cent, and agriculture about 1 per cent. Leaving public lighting out of the picture—for the aftermath of the war years must have considérably distorted the position there—the growth of consumption over the previous year's figures shows agriculture topping the list at 19·6 per cent, followed by commerce 10 per cent, industry 8 per cent, railways 6·4 per cent, and domestic under 2 per cent.

The provisional figures for the year 1950–51 reflect the more severe weather conditions and the inevitable distortion of normal spread of consumption due to the acute domestic coal shortage and increased power cuts; but agriculture again leads with an increase of some 20·7 per cent, followed by commerce 17 per cent, industry 12·7 per cent, domestic 10·9 per cent, and rail 4·3 per cent. The comparatively high increase for agricultural purposes (which in any event make such a small call on available capacity) we cannot but welcome, for every possible effort must undoubtedly be made to increase food production in this country.

If the industrial consumption figures are further analysed they show that the public supply of electricity to industry has approximately doubled since pre-war, although the increase per operative is not so high owing to the intervening growth of employment in our manufacturing industries. Nevertheless, the inadequacy of even this outstanding increase is revealed if we compare the power position of our manufacturing industry as a whole with that in America, where a deliberate policy is followed of heavy capital expenditure in order to economise in the use of labour.

Taking all sources of power, public and private together, the use of electricity per operative worker in the manufacturing industries of Great Britain increased from an average of 2365 units a head in 1938 to 3200 units in 1949, which is the latest year for which comprehensive comparative data are available. In the United States the consumption per productive worker increased over the same period from 8300 units a head to 11,700. In this country the increase has been just over 35 per cent, in America it has been 41 per cent. Whereas in 1938 America was using 3·5 times the power per operative, now she is using 3·65 times. Some part of the difference between the scales of utilisation of electricity is due to the different nature of our industrial structure, but every team sent out by the Anglo-American Council on Productivity reports on our relative deficiency in the use of power, and it is clear from the figures just given that we are actually falling back rather than improving our position.

Capital Development Needs

The point which I have endeavoured to bring out in this approach is the indisputable fact that if a nation is to improve its productive effort it must be prepared to spend capital in such a way as to secure the highest economy and efficiency in the long term. This was one of the main justifications for nationalisation of the electricity supply industry; but the national interest will be gravely impaired if the advantages of a closely integrated programme of development

in such a vital industry have to be sacrificed to temporary national embarrassments. The advantages which could flow from proper capital development are almost beyond assessment in the part which they could play towards improving the national economy as well as the efficiency of the electricity industry itself. Nor are the secondary effects without considerable importance, as one or two examples which come immediately to mind will show.

The Minister of Fuel and Power recently hazarded the guess that power cuts last winter cost the country between £8 and £10 million worth of industrial production. The saving of this would cover the capital charges on a substantial amount of generating plant, transmission and distribution capacity. If we had, say, 1,500,000kW of additional capacity, not only would power cuts be avoided, but the installation of the modern efficient equipment would result in a saving of some 1½ million tons of coal per annum (or, say, £3½ million per annum).

Again, the electrification of the railways would result in the saving of some 15 million tons of good coal, by the substitution of 5 million tons of inferior coal at power stations. And yet—although coal is likely to remain one of the biggest national problems—the nation's difficulties may defer the date when the full expenditure involved in railway electrification on the wide scale can be incurred.

Even on the straight consideration of operational efficiency within the industry itself it must be remembered that while the average thermal efficiency of generation plant throughout the country is now about 21·5 per cent, the best fifty stations are averaging nearly 25 per cent while the best individual stations reach 28–29 per cent. And an increase of only 0·1 per cent in thermal efficiency represents a reduction in coal consumption of roughly 140,000 tons, or an annual saving of some £350,000 !

In addition to the generation programme, there are the parallel problems of bulk transmission and distribution. Here we have already for some time had severe cuts imposed on the capital programmes submitted for Government approval; as a result we have had to restrict activities considerably and concentrate on essential work, on maintaining and strengthening the system so as to avoid breakdown. But it is unnecessary for me to emphasise to you that in a heavily expanding industry commitments do not remain stationary; both actual expenditure and "investment" (i.e., use of labour and material) inevitably gather momentum, so that we found that actual expenditure on accrued commitments already accounted for practically the full amount of last year's authorised total. There is thus little margin for new work; the result must soon be that very few new commitments can be accepted and even new supplies to industry and housing will accordingly run late.

If supplies to industry are delayed in this way or if they have to be refused, as may well be the case, not only will productivity in general be adversely affected, but, in parallel, the industrial investment itself will be wasteful to the extent that full working is delayed.

There is one further aspect of this question of capital investment which it is interesting to note when one is following up a claim for a larger share of the "national resources" cake. Critics of the present direction of the national economy are disposed to argue that the country is attempting to ride two horses at once; that it is attempting to develop its industry and trade to levels comparable, say, to those of the United States, while at the same time heavy burdens are being shouldered, to the detriment of industry, in order to maintain and improve the standard of living. A glance at the figures of gross investment in fixed capital by a number of European countries, published by the United Nations Department of Economic Affairs, tends to show, however, that this country is not out of step with developments all over Europe. Taking ten of the leading countries, the average industrial investment (i.e., including agriculture, fishing and forestry, transport and communications) in relation to the total investment in 1950 was exactly the same as the United Kingdom figure of 66 per cent., and the average social investment (i.e., including dwellings, government and other sections) was similarly the United Kingdom's figure of 34 per cent.

If these figures are further analysed, however, in relation to the industrial investment, we find that investment in electricity, expressed as a percentage of the gross investment for fixed capital in industry as a whole, lags considerably, at 19 per cent for the United Kingdom, as compared with 24 per cent for Norway, 26 per cent for France and 28 per cent for Italy.

There is a sense in which the electrical industry's achievements are so closely interwoven with national achievements that we might usefully pause to consider the criticism of over development of social amenities. Everyone here fully shares the view that the domestic consumer, and the housewife in particular, has the right to expect an appreciable increase in the supply and use of electricity for domestic purposes. Indeed, this is one of the fields of development which can be expanded with the greatest advantage not only to our standard of living, but also to that of the electricity supply industry itself. Moreover, it is important to appreciate that the peak load is estimated to be roughly as to two-thirds for industry and commerce and only as to one-third for domestic purposes. This means that the field for peak curtailment outside industry is limited. Yet we must recognise that particular uses of non-essential electricity are apt to coincide with times of peak demand.

It is obviously only with great reluctance that those associated with the industry are willing to consider the remedy that the normal individual finds it necessary to apply when demand outstrips supply. If we have to face a continuing deficiency of supply, how far can we condition demand to fit supply at its maximum available level? There must be unanimity everywhere about the need for finding a better solution than the blunt instrument of the "power cut."

The problem could be approached from the standpoint of (1) financial controls and (2) physical controls. So far as the price mechanism is concerned, in the present inflationary state of the national economy it may be doubted whether tariff adjustments or variations by themselves would suffice to reduce demand at the critical time-points. It might, indeed, aggravate the problem by worsening the industry's load factor. The Clow experiment certainly proved unsatisfactory as a means of restricting peak demand. Nevertheless, the future trend of prices may itself test the validity of the theory that electricity is at present so cheap as to remove incentive to economy, even at the time of peak demand; the need is already clearly foreshadowed for raising tariffs in order to cover increasing costs and to provide more substantial trading surpluses than the marginal sums so far achieved, which are scarcely sufficient to assist capital provision for plant expansions and plant replacements at the current high costs.

If, as seems inevitable, the gap between plant capacity and peak demand will persist for several years to come, greater reliance may have to be placed on physical means of controlling demand through some form of load controlling device; and it is significant that experiment and research are steadily proceeding in the direction of finding an efficient and acceptable means of control. This, it would seem, may be the only way of ensuring, so far as possible, that industrial supplies are given first priority. Such a policy would, of course, have serious implications and it would need to be accompanied by steps which would modify, so far as possible, all cases of personal hardship. By such physical means as can be employed it may be possible to bring a logical extension of load spreading arrangements into the sphere of domestic and commercial use. I cannot say more at this stage than that the Electricity Boards are very actively seeking solutions to these problems, which will be effective and practicable; whether they can be found is still "on the knees of the gods."

This position is again confused to some degree by the movement which is gaining ground—and rightly so—towards achieving the maximum efficiency in the national use of coal. There is a fundamental problem here calling for serious study and for the formulation of long-term national targets, looking ahead to the developments which we know to be in sight. The electricity industry has much to contribute to such a study and to the achievement of an eventual solution.

Finally, the industry's contribution to national survival and development carries with it the obligation to achieve the maximum practicable efficiency and economy in its internal administration. An ordinary trading concern has inevitably to review its charges in the light of (*a*) what the consumer will pay for its product, and (*b*) "profitability." It is a common criticism that these criteria are to a certain extent blurred in a non-profit-making organisation invested with monopoly powers in respect of an essential commodity.

This question is one of the most important affecting the nationalised industries. Many suggestions have been made for some form of external "efficiency audit," but all of them founder on the fact that such an industry as electricity supply is a complicated technical organisation, and that only a fantastic degree of technical duplication could provide any effective external check. There is no real substitute for the relentless pursuit of economy by the industry itself.

History may well prove that one of the greatest distinguishing features of the 1851–1951 century in Great Britain has been the birth and growth to maturity of a completely integrated electricity supply system. During the adolescence of the industry, when the opportunities were naturally many, inventiveness and enterprise went hand in hand to provide spectacular economies—typified by the 5 lb of coal per unit sent out in 1907 and the 1½ lb in 1950. Now, with so much of the possible technical economy already achieved, every new advance has to be fought for. The nation rightly looks to the industry to give proof of its maturity and stature by demonstrating its ability to conduct its own affairs "with due regard to economy and efficiency."

HANOVER TECHNICAL FAIR.—In our issue of June 8th, page 756, we referred to exhibits by Krupp of Essen. We are informed that this manufacturer is represented in this country by J. M. J. Maus, Ltd., 35, New Broad Street, London, E.C.2.

Standard Class "4" Mixed-Traffic Locomotives

WE are now able to give some particulars and reproduce a photograph of the smaller of the two 4–6–0 mixed-traffic locomotives of the six standard types of engine being built this year for British Railways. This Class "4" locomotive, the first of twenty, was built at the Swindon works. It is similar in many respects to the new Class "5" except that it is much lighter and will have almost universal availability over main and secondary lines throughout the country. The new locomotives are intended for duties of the kind at present worked by the obsolescent 4–4–0 engines in addition to certain other services.

The Class "4" engines have been designed and built under the direction of Mr. R. A. Riddles, of the Railway Executive, and many of their features are common with those of other standard British Railways' Locomotives.

The leading dimensions of the new locomotive are as follows :—

Cylinders, diameter and stroke	18in by 28in
Wheels, coupled, diameter ...	5ft. 8in
Wheels, tender, diameter ...	3ft 3½in
Wheels, bogie, diameter	3ft
Wheel base, coupled	15ft
Wheel base, engine	26ft 9in
Wheel base, engine and tender	50ft
Heating surface :	
Tubes	1301 square feet
Firebox	143 square feet
Total evaporative...	1444 square feet
Superheater	265 square feet
Grate area	26·7 square feet
Boiler pressure	225 lb per square inch
Tractive effort	25,100 lb
Adhesion factor	4·6
Weight of engine in working order	67 tons 18 cwt
Weight of engine and tender in working order	110 tons 1 cwt

Boiler Design

The boiler follows closely the design of that of the L.M. Region Class "4" 2–6–4 tank, except that the barrel is 9in longer, and as the boiler pressure has been increased from 200 lb to 225 lb per square inch the staying has been redesigned.

The Belpaire firebox is 8ft 6in long at the bottom, with an outside width of 4ft 0¼in, giving a grate area of 26·7 square feet.

A rocking grate has seven rocking sections, each fitted with fourteen renewable fire-bar units. The front and rear portions of the grate, consisting of four and three sections respectively, can be rocked separately from the footplate. Two flap doors in the bottom of the self-emptying ashpan are operated from ground level, and front and rear damper doors are controlled by screw gear and hand wheels in the cab.

A vertical grid regulator in the dome has its operating shaft placed transversely across the boiler and this shaft emerges from a stuffing-box on the second barrel ring. Connection to the regulator handle in the cab is through an external rod.

Two clack valves in the boiler are arranged for "top feed" and are placed approximately at 30 deg. on either side of the vertical centre line of the front barrel ring. Feed water is delivered on to two inclined trays, arranged to deflect the water around the inside of the barrel clear of the tube bank. A steam manifold fitted on the firebox top outside the cab incorporates separate shut-off valves to each steam supply pipe as well as a main shut-off valve. The two safety valves are arranged on the firebox top immediately in front of the manifold, and a manually operated blowdown valve is fitted to the front of the firebox throat plate just above the foundation ring for operation from ground level.

A cylindrical smokebox carried on a fabricated saddle is provided with the self-cleaning wire mesh grid. The blast pipe has a plain circular cap of 4½in diameter, and this contains also the four nozzles of the Cardew blower.

The engine has plate frames built up of 1½in thick mild steel plates braced by horizontal and vertical stretchers. Cast steel axlebox guides riveted to the frame plates, which are provided with manganese steel liners on the wearing faces, have lugs carrying pin-jointed cross stays to hold the frames in their correct relationship.

The boiler is carried in the frames by a rigid attachment between the smokebox and the saddle, whilst the rear end of the firebox rests on brackets which are integral with the drag-box and permit of fore-and-aft expansion.

Plain bearing axleboxes are fitted to all wheels. The coupled wheel axleboxes are steel castings, with pressed-in white-metalled horseshoe brasses. They have sliding underkeeps of ample oil capacity with pad lubrication, and these underkeeps are supplied with oil direct from a mechanical lubricator. The wearing faces in contact with the guides are provided with manganese steel liners welded to the axlebox, and lubrication of these is by grease. The bogie axleboxes are white-metalled bronze castings.

The laminated springs fitted to both engine and tender are built up of plates of carbon steel. Underhung spring brackets with rubber damping pads and tension links are provided for the coupled wheel springs, the links being solid with cotters at top and bottom ends. Link adjustment is obtained by fitting cotters of suitable depths.

Cylinders and Valve Gear

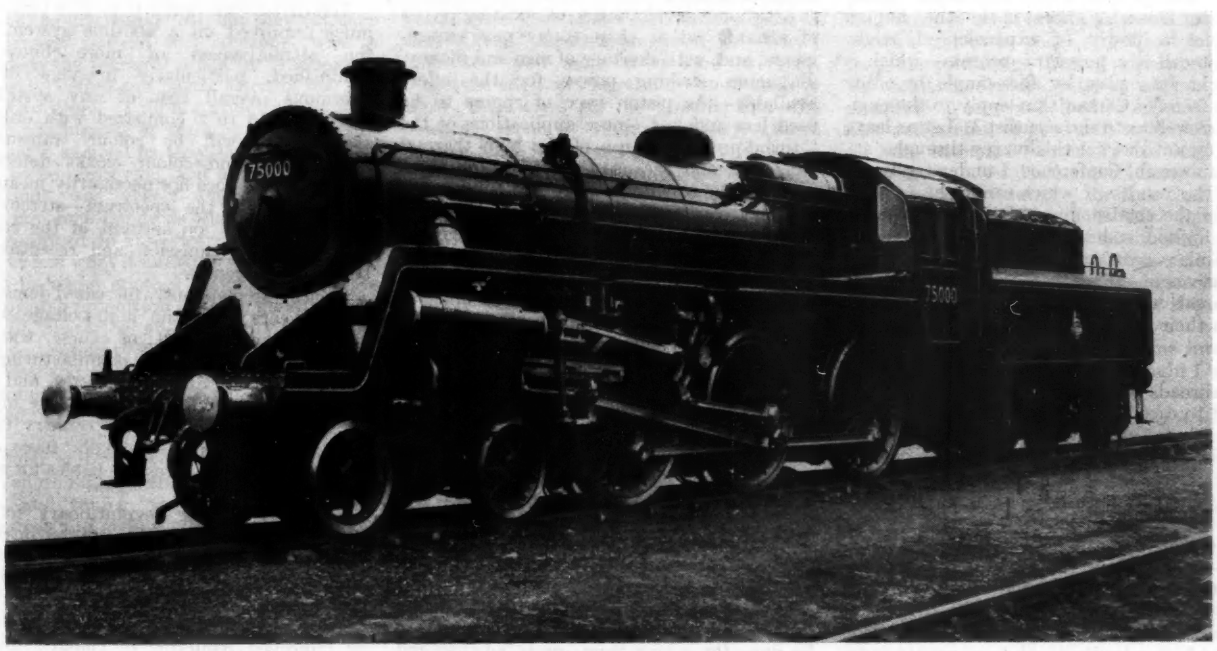
The two cast iron cylinders, which are placed outside the frames, have 10in diameter piston valves and are operated by Walschaerts' gear, giving a full travel of $7^{11}/_{32}$in, corresponding to a cut-off of 77 per cent with a steam lap of 1 1/16in and lead of ¼in. Three-bar slide bars are provided in conjunction with an underhung crosshead.

Lubrication of the cylinders and piston valves is by atomised oil supplied from a mechanical lubricator. The valve gear is lubricated mainly by grease and consists of plain bearing joints, except for the return crank rod big end which has a self-aligning ball bearing. The reversing gear is like that fitted to the other standard tender engines.

The 5ft 8in diameter coupled wheels have their tyres fitted in the manner which has been adopted for all standard locomotives in which the tyre has a small lip on each side to secure it to the rim of the wheel centre. This lip on the inner side is sufficiently shallow for the tyre to be expanded to enable it to pass over the rim. Fifty per cent of the reciprocating masses are balanced. Steam sanding is provided to the leading and driving coupled wheels for the forward direction and to the driving pair also for reverse running.

The bogie employs laminated springs in compensating beams and side bolsters, side play control being effected by means of double-coil springs. The bogie wheels are 3ft diameter.

The cab, whilst more restricted in space than that fitted to the larger standard tender engines, owing to the smaller loading gauge to which this



STANDARD 4-6-0 MIXED TRAFFIC LOCOMOTIVE

locomotive is built, follows the same lay-out as that approved for all the standard locomotives.

The tender is smaller than that fitted to other standard locomotives, but follows the same pattern. It runs on six wheels of 3ft 3½in diameter, and its axles are fitted with Timken roller bearing axleboxes placed outside the wheels. Steam brakes on both engine and tender can be operated by means of a separate steam brake valve, or in conjunction with the vacuum brake. The coupled and tender wheels are braked by means of a single block on each wheel.

Work, Education and Service of Engineers

JOINT ENGINEERING CONFERENCE

THE closing session of the Joint Engineering Conference was held in the Great Hall of the Institution of Civil Engineers last Friday afternoon, June 15th. That evening there was a dinner at the Connaught Rooms, at which the proceedings were finally brought to a close. At the afternoon session Mr. A. C Hartley, C.B.E., M.I.C.E., M.I.Mech.E., President of the Institution of Mechanical Engineers, was in the chair, and was supported by Mr. W. H. Glanville, C.B.E., M.I.C.E., President of the Institution of Civil Engineers, and Sir Archibald J. Gill, C.B.E., M.I.E.E., President of the Institution of Electrical Engineers.

Lord Reith, in an Address, officially bringing the Conference to a close, said :—

Somebody—not an engineer—said that a speech should fall into three parts :- the relevant, the irrelevant and the sob-stuff. Let us get on with the first, a quick survey of the ground covered in the past fortnight.

Thirty-five papers on eighteen subjects—engineering progress in the last hundred years—contributions to the advancement of civilisation—the part that this country played therein. Much trouble went to the preparation of those papers, much experience, a good deal of wisdom, and some imagination, too. Imagination ? That prompts a diversion. "Bounded and conditioned by co-operate reason, imagination becomes the mightiest instrument of the physical discoverer, and Newton's passage from a falling apple to a falling moon was at the outset a leap of the imagination." Thus Tyndall, in 1870 ; and, though he was speaking of and to scientists, is not some message there for an engineer ? Listen also to this : "There is in the human intellect a power of expansion—I might almost call it a power of creation—which is brought into play by the simple brooding upon facts." Cannot that apply to the engineer as well as to the scientist ? Let us leave that by until we get this survey through.

A successful Conference, I understand, and one, the results of which cannot be assessed within the conditionings of the spoken word to a limited audience in a limited time ; a particular satisfaction that eminent representatives of the profession from other lands have sat with British engineers and made plain their interest and their country's part.

Work

Railroads—with the rails changing from wood to cast iron, from cast iron to wrought iron, from wrought iron to steel ; with longer lengths of welded rails to come—traction by steam, internal combustion, and electricity, all developing along parallel lines for some time to come, with no great increase of speed or weight—improvements in signalling—greater safety. In bridges, a combination of prestressed concrete and welded steel ; perhaps more use of light alloys. As to the underground lines, tunnel construction methods standardised—cheaper now to build new tube lines than to widen roads—no railways driven in the Central London area since 1907—103 miles to come, at a cost of £340,000,000.

Sea transport—the increasing importance of rapid and mechanical handling of ships in docks, their loading and unloading—new types of equipment—the flexibility of electric power a great advantage. It is surprising to read that, despite all this, cargo handling throughout the world has slowed down. A tendency to build ships of greater beam but not greater length—dry docks becoming obsolete, but one which can take the "Queen Mary" likely to be able to take any ship to be seen, mercantile or war—a tendency towards more oil fuel, more motorships—the four-cycle diesel to disappear—the opposed-piston type to survive—the steam turbine for larger ships likely to be unchallenged for many years, but the gas turbine to come up—and so reciprocations give way to simple rotations and perhaps electric propulsion more than in the past.

Power—beginning with the water mill and water wheel—the prime mover—schemes to provide power for existing needs or new demands created to use potential supply—and now long-distance transmission and the connection of steam and water power stations to the national grid has brought development to unexpected quarters. Shortage of capital and of raw materials means more economy and more speed of construction—greater fuel savings are to be expected—one of the means, the use of a suitable combined gas and steam cycle—water power schemes in Asia and Africa, that I happen to know something about, will open up vast areas of hitherto barren land.

Aviation—development of existing types of aircraft rather than costly new experiments, and, with shortage of men and money, maximum striking power for the effort available—the piston type of engine to be used less and less—more applications of the "turbo-prop" because of the high thermal efficiency, and because there is a high-speed propeller to go with it—but still a no man's land between aircraft and engine designers, and a no man's land is dangerous. Dangerous also the disagreement on the radio navigational aids. On airfields, the short grass runways have given way to flexible pavement—the use of refractory pavements, and the elaborate systems of making them as we see them to-day.

Coal mining—a lot to be done. Greater safety—more use of mechanical plant—better lay-out, both below and above ground—a better communication system throughout the mine—mining technique to be determined largely by the manner in which the coal is to be used. Ideas of production and of distribution will be radically altered if, for instance, there is to be underground gasification.

Road transport—the system utterly inadequate—little being done, and little likely to be done for a long time—as to engines and vehicles, almost as many opinions as there are experts, but the compression-ignition engine still the favourite for the commercial car.

Public health—in street cleaning, the increased use of the motor sweeper to get over labour shortages—pollution of watercourses by industrial effluents to be dealt with — burials — bath-houses — abattoirs — smoke abatement—the increasing importance of the collection of rubbish. Water supply—plenty of water, but badly distributed—it is almost inconceivable how much of this island is still unwatered and unpiped—grids for water may be as important as grids for power—combined schemes for water supplies and hydro-electric power to be investigated. Sewerage—research mostly directed to modifying the nature of the effluent—new methods of sewage disposal to be evolved—much scope for the salvage of industrial wastes—and, despite opposition from farmers, we are told that, with improvements in supply and transport, sewage sludge may better compensate for the lack of stable manure than will chemical fertilisers.

Steel—the blast-furnace and the steel mill already so efficient that nothing much by way of improvement can be expected—the trend is towards bigger units and continuous operation, with just a hint of the possibility of an entirely new method—high costs are making people search for reductions in weight and for simplification, but, of course, that might apply anywhere.

Gas—a wide field here, as the industry markets not only coal gas, but many other fuels and by-products—the cost of the main product considerably affected thereby. There is dependence on a balanced production of residuals. Thermal losses in carbonisation hearths—alternative methods of complete gasification of coal should be available before long.

Electrical measuring instruments—the progress of all the sciences depended until recently on a few basic, classical types of instrument—the galvanometer, the electrometer, the bridge network, the potentiometer, the magnetometer—and civil and mechanical engineers here, if nowhere else, depend on the electrical. The quartz clock has raised the precision of time measurement to such a degree that even the irregularities of the earth's rotation are disclosed.

Television—the quality of the picture so much improved on a 405-line system that the attractiveness of more lines has diminished, particularly in view of the enormous overall cost of any system of television, 16 to 1 compared with ordinary radio—there will be colour transmission before long, and colour cloaks defects in definition and does not necessarily mean any more space in the spectrum—stereoscopic television seems, on account of the cost of production, transmission and reception, to be somewhat remote.

Cables—tremendously increased demand of recent years from the high-voltage transmission networks—but, of course, with the highest ranges of voltage manufacturing and testing plant are extremely costly, and costs increase as demand decreases. The highest transmission voltage in this country to-day is 132kV, but cable makers have been asked to design gas pressure cables for a projected grid of 275kV.

Lighting—nothing revolutionary forecast there, nothing comparable to the introduction of the gas-filled and the fluorescent lamp. Specialised production work for the high-pressure mercury-vapour lamps will provide extreme brightness, and there will be improved rendering of colour. Modern plastics, non-conductors and electrically and

chemically inert, will replace metal in the fittings.

Telecommunications—the first exchange in 1879 in London, with eight subscribers—thirty years later, in 1909, half a million in the country—in 1939, 3,300,000—to-day, 5,200,000—and comparatively little change over all that time in the two essential instruments, the transmitter and receiver, the chief development being automatic switching in the exchange. Simultaneous transmission of more than one message over one wire, a British contribution—the British cable system unique and the envy of most other countries in the world—the submerged repeater British in origin.

Radio—work on long waves, medium waves, short waves and very short—studies on the effect of the ionosphere on their passage.

Education

Finally, education and training. I should like to go a little slower here. Full-time education in the universities and technical colleges, or part-time courses running concurrently with practical training. We know all about it. Attention being paid, so we hear, to technical college education at all levels—professional, the technician, and the craftsman— and some of it pretty inferior !—a lot of rationalisation needed in the technical colleges themselves ! As to post-graduate courses, other than for the research worker, are there any ? Certainly not many. Rather odd, is not it ? Most, if not all, other professions have them ; why is engineering education different ? Less need ? Less demand ? Whilst we are at it, is not there some cause for concern about the overall education of the average engineer ? Is he as well educated as those on similar levels in other professions ? All round as well as even professionally, is he as well educated ? Anyhow, you have been hearing expressions of alarm at the inability of engineering students to think and write logically, and we can leave it at that for the moment.

As for practical training, you have heard that it has been an integral part of the English industrial system, traceable back to the thirteenth century, when all the trades manufacturing goods were under the control of the guilds. It may be it was better done then than now. At any rate, apprenticeships can still be utterly farcical, but they say that the present pattern will continue, with a period on the practical side after graduation, or partly before and partly after, of not less than two years. I do not myself think that either educational or training arrangements are nearly as good as they should be. They seem to be improving, and among the many thousands who yearly emerge I suppose there are some hundreds who are reasonably well equipped to start learning—for that is more or less what it amounts to.

Let us make another assumption, that a recognisable proportion of those hundreds are men of character and integrity, common sense and assiduity, ready and eager to serve their day and generation, to accept responsibility, men with courage to venture and faith to lead. Let us assume that. Qualities, mark you, which in these days can be unpopular and inconvenient qualities, which the Welfare State, with so much emphasis on rights and taking, so little on reciprocal obligations and giving, may find, if it has not already found, at a tragic discount amongst its citizens—an atmosphere which is strange and uncongenial to the engineer.

But let us assume that they are there, the engineers that the times and the circumstances demand—for more than ever the engineer is in demand, the engineer of every kind, his part vital and determining. Incidentally, the interdependence of the three great institutions, or rather of the three branches of the profession, is more and more obvious and recognised, and co-operation amongst the three is increasingly practised. I apologise if this is untactful, but I found myself wondering, why three alone ? And even within the three there is something that wants explaining, if not rationalising, in the significance of the name of the institution to which I belong, and, if it can already include so much, one wonders why the builder of a dam or a bridge is an engineer, but the builder of a ship or a house or a flying machine is not, whether in fact the engineer is never an architect nor the architect ever an engineer.

Oh, yes ; the engineer is very useful in these days ; more and more so. More and more people depend on him ; more and more the State depends on him. There are many occupations which are neither essential nor of real service, which could be eliminated without loss to the community, indeed, with positive benefit to the community. Not so the engineer. He is a faithful and essential servant of the community. Too much of a servant, perhaps ? It may be !

Service

I am going to read a letter which will bring me to the point. It was written by the President of the "Civils" on January 23, 1940. It was written to me, but that is neither here nor there. It might have been written to any one of you, any one out of the ten thousand. Listen :

"I am writing to inform you that it was the unanimous wish of the Council at their meeting to-day that their warm congratulations be conveyed to you on your appointment as a Minister and on your having been sworn in as a Privy Councillor."

Listen to what comes next—extraordinary words, I think they are :

"This is the first occasion on which a Corporate Member of the Institution has entered the Cabinet, a distinction on which the engineering profession may feel pride and satisfaction."

A courteous, kindly letter, much appreciated ; but does not it surprise you, when you think of it ? Why ? This is the first occasion—after all, quite a modest occasion, but the first time that a corporate member of the "Civils" had encompassed it. Why ? "Maybe," you may be inclined to reply, "because engineers have more sense than to allow themselves to be drawn into the political arena," where certainly things happen that would not happen, and would not be allowed to happen, on any ordinary, properly-conducted engineering job.

I agree ; and often I wished, when in that arena, that engineering codes of procedure did there apply ; but that would only be playing with the issue. Do you see what I am getting at ? It may be that engineers have for too long been content to be servants, that it is time that they had more of a hand in the governance of the country, that it would be greatly to the benefit of the community, the country and the world if they had. Is not there a great deal in the engineer's outlook, his training and his methods of procedure that is applicable in other, broader fields, and urgently needed there ? Is there an inferiority complex in the profession ? Are its members trained to live behind the green baize door, to eat below the salt ? "Engineering, the most arduous form of idleness." What did Robert Louis Stevenson mean by that ? I suppose that he could not see any employment of the intellect and could not imagine the engineer as a governor. Whether or not it still is I do not know, but certainly engineering used to be the dumping ground for the indeterminate.

Servants are not so much interested in the assessment of the contribution that the engineer has yet to make to civilisation. I am much more inclined to speculate as to what civilisation is likely to do with that contribution, with the integration of all the contributions of all the engineers. If civilisation is set on making a fool of itself and a scandal and a shame, or is likely to do so, then, of course, it is making a fool and a scandal and a shame of engineers, who have put it where it is. If it is set on destruction, it will be a comprehensive destruction. But it may be that here is one of those providential examples of the sum of the parts being far greater than the whole. Here, perhaps, the lifting of the load of care, of bewilderment, of fear, may be accomplished by one section of the community which dedicates itself thereto—a task for the engineer.

The conception of the job ahead, the upthrusts of imagination, the designs and the plans, the quantities and the estimates and the counting of the cost, the deployment of effort—all this is normal to the engineer. The relation of effort to result with a due factor of safety, the study of objective possibilities and then of machinery and operation —there is efficiency in the engineering sense, that wonderful word, and as the engineer understands it. That efficiency, and a straightforward determination to reach the objective, seem to be what we need in our broader relationships and doings, and in all our perplexities, national and international.

Just as I have made no reference to nuclear energy and the revolutionary changes which it will surely bring, so I make no reference to ethics or the moral law, no reference to the wisdom of which the depths and the seas say it is not with them, that it cannot be gotten for gold nor silver be weighed for the price thereof.

Having written that, I rose this morning from my desk, drew back the curtains to let in the light, opened a door out on to the grass, the green grass and the beginnings of another day, not knowing what it might bring, except that I—to whom, transposing the words of that President's letter, it is a matter of pride and satisfaction to be a corporate member of the Institution of Civil Engineers, a pride and satisfaction that will go with me to the end—that I had to speak to some colleagues in the profession, close the Joint Conference with an expression of gratitude to all who helped to make it agreeable and useful, of good will to them and to all who attended, especially to those who came from other lands, and return to my garden door by sunrise, for it is there that I will take leave of you in these immortal words. "An odd ending to an address to engineers," you will say, "when there is nothing directly or specifically engineering in it." All right ; more's the pity if you do think it so very odd.

These are the words that came into my mind at sunrise to-day, that I thought I would pass on to you :

"Sweet is the breath of Morn, her rising sweet,
With charm of earliest birds ; pleasant the Sun,
When first on this delightful land he spreads
His orient beams, on herb, tree, fruit, and flower,
Glist'ring with dew ; fragrant the fertile earth
After soft showers ; and sweet the coming on
Of grateful evening mild ; then silent Night,
With this her solemn bird, and this fair Moon,
And these the gems of Heaven, her starry train."

The Chairman then called on Sir Archibald Gill, President of the Institution of Electrical Engineers, to speak.

Sir Archibald felt that the Conference had undoubtedly been a success. To be frank,

they could sometimes have wished for larger audiences at the reading of the various papers; on the other hand, they could not have hoped for better discussions. They were particularly pleased that so many visitors volunteered to add their contributions, and the special Conference volume which was being produced by the three Institutions would be, he said, an admirable record of the progress of engineering during a hundred years. Indirectly, but not intentionally, the Conference had served to illustrate the mutual interdependence of all the branches of engineering. In the Councils of the three Institutions they had come to take that for granted, but it was not often that it was so clearly shown as in the way in which the papers presented to the Conference had dovetailed one into the other, when their origins lay in different branches. He would like to emphasise one of the morals of this lesson, a moral which, incidentally, came out quite frequently in the education and training discussions on Wednesday last. It was more than ever clear that their education and training policy must be based on directing the attention of their undergraduates and students to the ever-widening fields of fundamental science and to the need for eschewing until the post-graduate stage any tendency to any form of specialisation beyond the principles governing the branch of engineering chosen by them in their last year before graduation.

The Chairman then called upon Dr. Glanville, President of the Institution of Civil Engineers.

Dr. Glanville said that the Lord Privy Seal gave the Conference a fine send-off and Lord Reith had given it a splendid conclusion. They were indeed grateful to Lord Reith for undertaking the formidable task of dealing with the work of the Conference, covering, as it did, such a very wide field. They congratulated him on addressing them with such humour, skill and understanding, and particularly on not sparing his comments where he thought criticism to be necessary.

Mr. J. C. Forsyth, of the Commonwealth Conference, and a delegate of the New Zealand Institution of Engineers, then expressed to the members of the home Institutions, not only on behalf of the New Zealand Institution of Engineers, but also on behalf of the other Commonwealth Institutions, their very sincere thanks first for the invitation to be present, and secondly, for the most useful and enjoyable experience which they had been given in London. Mr. L. Paavolainen, of the European Conference, a delegate of the Finland Institution of Engineers, on behalf of the representatives from the European Engineering Institutions who had been invited to participate in the Conference, said that they were very grateful for the lectures and papers which they had heard, and their most earnest wish was that the relations between their countries and Great Britain might be strengthened and developed in mutual understanding and good will.

The Chairman, before declaring the session closed, added his own thanks to Lord Reith for his inspiring address.

Sulphur Deposits in the Andes.—A mission, headed by Mr. J. M. Langley, has recently completed, on behalf of Fisons, Ltd., an investigation of the largely untapped deposits of sulphur in the Andes chain. Several of the mine workings inspected were situated at an altitude of 20,000ft, the workings frequently taking the form of a tunnel bored into the mountainside. Because of the austere working conditions, output from these Chilean sulphur mines has been small, but the deposits are extensive, it being estimated that they contain 20,000,000 tons of ore.

A West Country Engineering Works

RATHER more than 120 years ago, a Mr. Twose set up in business at Halberton, near Tiverton, Devon, as a maker of agricultural implements. It seems likely that his establishment was little more than a village smithy. Tradition has it, however, that Twose invented a grass seeding machine, which he one day pushed on a wheelbarrow to South Molton market, 20 miles away. But he did not succeed in finding a purchaser there and was compelled to push it home again to Halberton. Nevertheless, his business progressed and the original Twose and his descendants have become well known as West Country manufacturers of cultivators and other agricultural implements.

The expansion of the business led in time to the Halberton premises being used for retail sales and repair work, the manufacturing side being transferred to a works in the nearby town of Tiverton. There, for many years, implement production was continued under the direction of the Twose family, the last of whom to take active participation in the business being Mr. E. V. Twose, who retired in 1942 and still lives in Tiverton. In that year the company, named E. V. Twose, Ltd., became a subsidiary of John Heathcoat and Co., Ltd., an old-established industrial undertaking in the West Country. Recently we were invited to be present on an "open day" at the works of E. V. Twose, Ltd. The occasion may well be described as a "house warming," for it signified the official opening of new shops which have been built and fitted out during the past year.

This new factory building—known as the Lowman Works—has a floor space of about 12,500 square feet, and is well lighted. It has been designed on flow production lines for the batch manufacture of agricultural implements. Most of the castings required for the Twose implements are produced by Exeleigh Foundry, Ltd., Tiverton, which is also part of the Heathcoat group, while another associated company supplies timber from local sources. Well-arranged stores have been provided at one end of the new factory, and from them materials pass to the machine shop, and thence to the welding and assembly bays. Finally, the implements go for finishing to a completely enclosed paint shop, passing out at the other end of the factory for dispatch by rail or road transport.

After inspecting the new works, visitors were taken on the "open day" to the firm's trial ground near Tiverton, where there was a field demonstration of some of the implements which are now being produced at the factory. Among the implements shown at work were a tractor-mounted seed drill, a verge trimmer designed for operation with the hydraulic linkage of the Ferguson tractor, and a tractor-mounted fertiliser distributor. The two first-named implements are the most recent additions to the firm's manufactures. The seed drill consists of individual seeding units arranged at intervals along the crossbar of an open frame, the actual sowing taking place on the spacing principle instead of continuously. Each unit carries a revolving seed plate through holes in which the seeds drop into a flexible tube. A rotating brush mounted above the seed plate keeps the holes clear. The accompanying illustration of an assembly bay in the Lowman Works shows the assembly of the seed drill in progress. Tractor self-lift cultivators, drag harrows, and a lateral toolbar are other implements constructed by the company, and at the demonstration there was also shown the prototype of a shallow ditching machine for digging drainage trenches in water meadows.

During our visit it was particularly interesting to learn that E. V. Twose, Ltd., has always made a point of studying the particular problems and machinery needs of West Country farmers, and that in developing new implements the local farming community has always been ready to co-operate. It should be said, however, that that policy has in no way militated against the firm's business activity in other parts of the country and overseas.

Assembly of Seed Drills

Part of the new Lowman Works is occupied by another Heathcoat subsidiary, Stenners of Tiverton, Ltd., which manufactures woodworking machinery. This business was founded in 1870 by a Mr. Joseph Stenner and originally its activities included general and agricultural engineering in addition to the production of sawmilling equipment. Subsequently, however, the company concentrated solely on the output of log conversion and joinery machines. Since joining the Heathcoat group in 1943 the firm has made further developments, its products now including machines to deal with most of the basic woodworking operations from log bandmills, capable of dealing with the tree in its first stage, down to such items as sawbenches, bandsaws and spindle moulders.

Improvements at Leicester Motive Power Depot.—British Railways (London Midland Region) is to begin the installation of mechanical coaling and ash-removing plants at Leicester motive power depot in six months' time. Other improvements which will be carried out in the depot include the installation of electric light in place of gas, additional buildings for offices and staff amenities, and the provision of a canteen. A better lay-out of the tracks in the depot yard will facilitate the movement of locomotives to and from the shed.

The Place of Plastics in Industry*

By Sir BEN LOCKSPEISER, K.C.B., F.R.S.

In recent years synthetic materials, particularly the man-made fibres, have so captured the public imagination that there is a tendency to look to plastics as a way out of the current shortage of raw materials. But this is to ignore the economics of the matter. World production of cotton, wool, natural rubber and wood ranges from wool at 1·6 million, cotton at 6 million, rubber at 1·5 million to timber at about 1000 million tons. The only synthetic material approaching the million-ton figure is rayon, at a world production last year of 1·6 million tons. Production of all other plastics put together totalled just over a million tons. To replace only 10 per cent of the world wool output at its present level of 1·6 million tons per annum by synthetic material would involve a capital outlay of between £300 to £400 million, and if the whole of the capital employed in the British plastics industry were applied to ease the wool or cotton supply, the total quantitative effect would be little over 8 and 5 per cent respectively of the British imports of these materials.

It is not necessary to allow either extravagent hopes or the difficulties of the future to distract attention from the achievements of the present. Within its existing resources the plastics industry has a considerable role to play in the conservation of certain relatively scarce materials, by providing better ones. In the electrical industry, in particular, the problem of replacement of lead as a protective sheathing in communication cables has become acute. The alternatives are either another metal or a synthetic material, and of these aluminium, polythene and polyvinylchloride have shown the greatest promise. Polythene especially has been found suitable for some types of cable in circumstances where resistance to corrosion is an all-important factor.

In the domestic sphere plastic materials have been developed which can be shaped and threaded and will keep their shape even when used for conveying hot water, waste and even corrosive liquids.

The greatest use for materials alternative to leather lies in the making of boots and shoes, since 80 per cent of the leather output of this country finds its way to footwear. It is for soling material that the use of leather is most seriously challenged by rubber composition and particularly by the resin rubbers of American origin. About 25 per cent of the footwear in this country and 60 per cent in the U.S.A. employ soling material other than leather, and, of the latter, the recently developed resin-rubber neolite, a material largely originating from styrene, appears to be the most popular.

Natural rubber is still supreme where the main requirement is maximum extensibility and resistance to wear, but otherwise for electrical insulation for wires and cables, a non-inflammable covering of good resistance to normal deteriorating factors, polyvinyl chloride can be applied with only minor alteration to existing machinery. Other insulating materials, such as polystyrene and polythene, possess such desirable electrical properties that they make possible the satisfactory insulation of ultra-high-frequency cables. There are also wide possibilities for the blending of plastics with synthetic rubbers for the purpose of improving the processing and extrusion characteristics and the tensile strength, hardness and toughness of these rubbers.

For the production of aircraft the waterproof properties of laminated wood and the strength and wear-resistant properties of densified wood bonded with synthetic resin are by now well known. The great success of plastic bonding, wood to wood, led quite early in the war to experimental work on the bonding of metal to wood for certain parts of the "Hornet" aircraft, and later to the bonding of metal to metal in the "Dove." Finally, in the "Comet," the elimination of drilling and of riveting in the construction of the shell by bonding metal to metal has been carried to its maximum by what has become known as the "Redux" process. Its many advantages outweigh the high capital costs incurred in providing presses, steam generators, tools, foundry and cleaning equipment. Nor should the reduction of noise—the modern curse—be overlooked with the consequent improved factory working conditions.

In the textile industry plastics and plastic bonded materials are increasingly employed for pulleys, cams, quiet-running gears, precision-moulded pirns, bobbins and other more complex parts. Such parts can be manufactured to the necessary limits of precision and smoothness by mass production methods.

Basic plastic materials have been developed which have brought about entirely novel fields of application. This is exemplified by the methacrylate polymers which, like polythene, are a development of British origin. From early use as denture plates and the perspex windows of aircraft, their optical properties have rendered them unique for contact lenses, television lenses and diagnostic instruments. A further exceedingly valuable property of some transparent plastics is that by which stresses induced in a heated model can, as it were, be frozen into the material by cooling under load. The photo-elastic pattern remains when the load is removed and can be examined, three dimensionally if necessary, at leisure.

As distinct from plastics proper, the ion exchange resins function solely on account of their chemical properties by forming insoluble complexes with metallic ions, on the one hand, or with acidic ions on the other. This property was put to use in Germany during the recent war in the recovery of copper from cuprammonium wastes and silver from photographic wastes. Much attention is now being directed to the possibility of economic recovery of zinc from pickling acids and of nickel, cobalt, gold and other precious metals from plating liquors. In many instances the technical feasibility of an ion-exchange process has been demonstrated, but the economics are still uncertain.

The British Printing and Allied Trades Research Association had examined over a considerable period the possibilities of eliminating the use of graphite, and the attendant unpleasant conditions of operation, in the electrotyping process. The electrodeposition of copper on wax without the use of graphite was eventually accomplished. Faced with the problem of finding a material which would mould with fidelity, which had a shrinkage not above that of wax, and which would not shrink in the plating bath, this research organisation tested all available plastics. Eventually, in co-operation with the British Rubber Manufacturers' Research Association, a specially compounded ebonite, "patramold," was produced which not only possessed all the requisite features, including a shrinkage coefficient of only one-third that of wax, but presented the remarkable advantages of supreme ease of removal from the copper shell in boiling water and of recovering at once to a flat surface ready for remoulding.

A new field of specialised application has been opened by the introduction, comparatively recently, of the fluorine plastics. One of the fluorine compounds, polytetrafluorethylene (known as P.T.F.E.), is not only remarkable for its ability to function at relatively high temperatures, up to 250 deg. Cent., and for its almost complete resistance to corrosion, but also for its outstanding anti-friction properties. Its friction coefficient is comparable with that associated with ice. It has the disadvantages, however, of being a poor conductor of heat, of having a high thermal expansion coefficient and a low modulus of elasticity. Work is in progress to overcome these defects by impregnating the pores of sintered metal with P.T.F.E. so that, for example, a bearing might be produced with the mechanical properties and thermal conductivity of the sintered metal and an impregnated surface with the anti-friction properties of P.T.F.E. This opens the possibility, as Dr. F. P. Bowden, who has pioneered in this field, has pointed out, of designing surfaces for the engineer with inherent and self-renewing frictional characteristics, suitable for the use to which the material has to be put.

* British Plastics Convention, Inaugural Lecture, June 6th. Extracts.

Back Projection in B.B.C. Television Production

We learn that back projection of scenery is now being tried out by the B.B.C. in one of the television studios at Lime Grove, Shepherds Bush. The equipment for the back-projection trials has been lent by D. and P., Ltd., from Pinewood Film Studios, and was first used in a television transmission on May 9th for the "Here's Howard" programme. It is also being used in the "Passing Show" series and in other programmes.

Back projection, or "process projection," as it is now often called, is widely used in the film industry to supplement scenery and real backgrounds. The process consists of projecting the image of a scene on to the back of a translucent screen to form the background; action then takes place in front of this screen, and the camera televises the whole scene, including actors, real foreground scenery, and the projected background.

The basic requirements for successful back projection in television production are the same as those for film production. The image on the screen must be bright enough for the camera in use, and the brightness must not fall off appreciably at the corners. Stray light must be kept to a minimum, or the contrast of the image will be reduced to too low a value. The image must, of course, be perfectly steady, and the projector must not make any appreciable noise. Other requirements which must be met if a realistic effect is to be obtained are that correct perspective should be maintained between foreground and background, and that the lighting should match. This means that the slide for the projector must be made from a photograph taken to suit the desired foreground, or that the foreground should be arranged to suit an existing background photograph. Since the edges of the screen must never be shown, the action when the floor is to appear in the shot must take place on a rostrum, or else the foreground scenery must be so arranged that the join between screen and floor is hidden.

The amount of camera movement possible on a set employing back projection depends on the type of set, but is, of course, always limited by the edges of the screen. On a scene lacking in acute perspective, consisting of, say, a grassy bank on which the action takes place and a projected background of a distant landscape, the camera can be tracked and panned freely. On the other hand a scene consisting of, for example, a colonnade in which the nearest few columns are real and the distant ones projected, demands a fixed camera position. Most scenes fall between these two extremes.

At the moment the largest screen being used at Lime Grove is 18ft wide, and using the projector lens of shortest focal length the required throw is 37ft. The studio floor space taken up when using back projection is, however, reduced by using mirrors to fold the light beam. If back projection comes into general use it will make practicable some effects that are difficult to produce on painted backcloths and so give more scope to television scene designers.

Engineering Education.—The third edition of the pamphlet on engineering education in the London region has been published by the Regional Advisory Council, in collaboration with the Engineering and Allied Employers (London District) Association. The pamphlet gives general information about the various types of course available for students from the time they leave school. An outline is also given of facilities available for students who are qualified to follow courses for university degrees and research. There is also a list of the colleges concerned in the region, with the courses offered during the session 1950–51, which it is thought may be a useful guide on which to base enquiries regarding present or future facilities. The book can be obtained for 1s. net from the Council's offices at Tavistock House, London, W.C.1.

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FIFTY YEARS OF STANDARDISATION

LAST Monday there was opened at the Science Museum, South Kensington, London, a remarkable exhibition illustrative of the application of standards to industry. It has been organised by the British Standards Institution and it will remain open until June 28th. In the organisation and arrangement of the exhibition the British Standards Institution has obviously been enthusiastically supported by the many trade associations and technical bodies, the Post Office, British Railways, and individual firms with which it collaborates or co-operates in bringing about standardisation, or which are themselves, like the Society of British Aircraft Constructors, actively concerned in formulating standards. As a consequence it can reasonably be claimed that the exhibition is the first of its kind to be held on so comprehensive a scale. Many full-scale exhibits and models and a variety of other exhibits have been collected together to show to what an extent standards have influenced design, simplified production, improved quality, and contributed to the convenience of the user; and to what an extent the work of an Institution which, in its origins, was set up by engineers fifty years ago to study engineering standardisation, has since penetrated widely into fields only remotely connected with engineering, such as those of textiles, printing and stationery, process inks, chemical glassware and dairy work.

The value of standardisation is now so well recognised that it is difficult to believe that a body specifically set up to pursue standardisation should have existed for only fifty years. We are, indeed, inclined to wonder, looking back, how industry got along without it throughout the latter half of the nineteenth century! There had, of course, been national standardisation before the formation of the Standards Committee in 1901, from which the present-day Institution originates. For Governments, far into the distant past, have found it necessary to standardise such fundamental things as units of length, area, volume, time and money. But, presumably, because there was until then nothing approaching the mass production we know to-day, because in fact nearly all things were made by craftsmen to individual designs, and because there was little repetition, the need for national, as opposed to purely local, standardisation or standardisation within a single factory or group of factories was not seriously felt until late in the nineteenth century. Then, in 1880, Sir Joseph Whitworth began to advocate standardisation to secure interchangeability between different makers' products. He pointed out, for instance, the need to standardise candle butts and candlesticks (much as the need was urgently felt later to standardise electric lamp bulb fittings), and about the same time stressed the "convenience"—which we, to-day, would regard as a necessity—of standard screw threads. What, however, finally brought the matter to a head was the multiplicity of iron and steel sections, ranging only slightly in form and dimensions, supplied by different manufacturers. Mr. J. H. Skelton, an iron and steel merchant of London, was the prime mover in urging simplification of that range. In 1898 he engaged the attention of Sir John Wolfe Barry and the latter, in 1901, persuaded the Council of the Institution of Civil Engineers to appoint a committee to consider standardisation of iron and steel sections. In effect that committee has never since ceased to sit! The value of its work received such emphasis during the first World War that it was incorporated as the British Engineering Standards Association in 1918 and granted a Royal Charter in 1929; and the extension of its work into fields other than that of engineering made it desirable in 1931 to change its title once again to that it now bears, the British Standards Institution.

From the very start the Standards Committee adopted a policy that ensured that it would never come into collision with or incur the odium of industry. It set to work, and the present institution still sets to work, by seeking the agreement of makers, users and all others concerned that a proposed standard is needed and, later, upon the form the standard should take. It has always held firmly to the doctrine that standards must thus be voluntarily agreed upon, and it has resisted any suggestion that standards, once formulated, should be compulsorily imposed upon industry. In that resistance it received the firm support of the "Lemon" Committee, set up in 1948 by a Government impressed by the proved value of standardisation in the second World War, to examine the standardisation of engineering products. That Committee, although it had a number of proposals to make, designed to intensify the work of the Institution and speed up its operations, expressly rejected a suggestion that "measures of standardisation reached by common agreement should be enforced by the Government." Again, almost from the start the Standards Committee received Governmental financial support. For the year 1903–4, for instance, the Government granted it £3000. Under the recommendations of the Cunliffe Committee, appointed in 1949 to consider "the organisation and constitution of the British Standards Institution, including its finance," substantial financial support will be available for the future equal in amount to that provided by members' subscriptions. The first object of the original Standards Committee was to bring about dimensional standardisation of iron and steel sections. Dimensional standardisation has ever since constituted an important part of its work. But, as Mr. Percy Good pointed out in his Presidential Address to the Institution of Electrical Engineers in 1947, "the main objective of the national standards movement is the establishment of standards for quality, fitness for purpose and performance." To what a successful and beneficent extent that objective is being maintained by the Institution and the trade associations with which it co-operates can be learnt by a visit to the exhibition.

LONDON'S UNDERGROUND RAILWAYS

ONE of the more controversial aspects of future engineering development, and one which gave rise to a very good discussion at the Joint Engineering Conference, which concluded last week, was that of the extension of London's underground railways. A paper presented by Sir David Anderson, entitled "Underground Railway Planning and Construction," a summary of which appeared in our issue of June 8th, included descriptions of two projected underground routes, together with some estimates of their cost. It was apparent from the paper and the discussion that future development in the underground system will depend largely on whether economies can be made, for the cost of an underground railway is now so heavy as to hamper severely the authorisation of further construction.

An early example of a deep underground line, the Central Line, was constructed at the beginning of the century. Owing to its low capital cost of about £4¼ million, which was equivalent to about £600,000 per route mile, it paid its way and showed a profit for many years. However, subsequent underground lines have in general had to be subsidised. To-day the cost is between five and seven times that of the figure given above. The proposed extension of the Bakerloo line from the Elephant and Castle to Camberwell has been estimated to cost about £6½ million, or

about £4¼ million per route mile. But this particular extension has such a high estimated cost because of unfavourable subsoil conditions and a complex terminal arrangement. A second proposal, that of a line from Victoria to Green Park, Oxford Circus, Euston, King's Cross and Finsbury Park, later to be extended in both directions, was estimated to cost about £2 million per route mile in tunnel, and of the order of £3 million per route mile allowing for the minimum extensions to rolling stock depots on the surface. The civil engineering work involved in constructing the running and station tunnels accounts for about 43 per cent of the total costs which we have quoted. About fifty years ago the construction of deep underground lines was initiated because of the high cost of cut-and-cover measures. To-day it would appear that a similar break with existing methods might well be sought in order to achieve a similar reduction of cost. Congestion in the centre of London is so great that transport is forced underground, and in spite of the high cost of tube construction that system of transport still compares favourably on the basis of cost with the alternative of widening surface routes. But it is evident to anyone who has travelled through London in the rush hour that more transport is needed. For trains (and buses on the surface) become very uncomfortably crowded at those times. Underground railways have, of course, proved themselves unequalled for their capacity for handling crowds, and it is therefore to more underground routes, built more economically, that London will probably have to look to relieve rush-hour congestion. The paper and discussion to which we have referred were confined to the civil engineering aspects of the problem, but it should be noted that since less than half the cost is accounted for by the tunnelling works, the mechanical engineer and the electrical engineer also have scope for introducing economies. In the discussion several suggestions were made for changes in tunnelling methods, of which the most promising was probably that of discarding cast iron linings in favour of linings made of reinforced concrete segments. One method of using this form of construction embodies wedge-shaped segments; after a complete ring is erected the segments are forced together by the rams of the tunnelling shield, so that the ring presses tightly against the preceding ring and against the surrounding clay. The expensive process of grouting is thereby eliminated and, in addition, constructional economies are introduced by the method itself. An experimental tunnel of this kind has already been built in London to accommodate a 75in water main; it was described in THE ENGINEER of February 2, 1951, and we understand that tests are likely to be undertaken with a larger diameter tunnel suitable for an underground line.

There is another aspect of the matter not without relevance to this discussion. If economy in tunnelling costs is to be achieved, the men who do the work must become used to it. It was estimated in the discussion that some £4 to £5 million annually needs to be spent if an adequate number of tunnellers are to be offered regular employment. Further economies would follow from a practice which would permit a regular programme of works to be planned ahead. We have repeatedly remarked in this journal that short-sightedly the Government is not permitting enough capital to be expended on the improvement of transport in general by road and rail. Here is another example. For the inability of the London Transport Executive to continue that regular extension of the tubes that took place before the war is raising the eventual cost of works that, sooner or later, will have to be undertaken and which in fact need urgently to be put in hand if further and scarcely tolerable congestion is not to occur in rush hours.

THE STEEL SCRAP DRIVE

STEEL production during May, which, as reported in our last issue, was at an annual rate of 15,864,000 tons, showed the effect of smaller imports of iron ore in the winter period, and also the effect of last month's exceptionally low import of scrap. Only 26,000 tons of ferrous scrap were imported in May, compared with 196,000 tons in May last year. At the same time, it is encouraging to know that over the first five completed months of this year British steel output was at an annual rate of 16,361,000 tons—an achievement which would not have been possible but for the success of the scrap drive which was initiated last January by the British Iron and Steel Federation. It was expected that, without any special drive, 157,500 tons of scrap a week would be forthcoming from home sources this year, although in some quarters it was felt that that might be too optimistic an assessment of the situation. The object of the drive was to add 10,000 tons of scrap a week to that figure from the end of January.

Last week, the British Iron and Steel Federation was able to announce that the special effort had led to the receipt of a weekly average of 167,500 tons of iron and steel scrap between February and May, an amount 10,000 tons above the weekly average last year. This commendable achievement has resulted from the energy of the British Iron and Steel Federation, the Joint Iron Council and the Scrap Merchants' Federation, and the work of the nine district committees, representing scrap merchants and steel makers, which were formed at the beginning of this year. But it must be remembered that, during the first quarter of 1951, the average weekly consumption of scrap was 180,000 tons. To maintain a high rate of steel production for the rest of the year increased quantities of home scrap are essential. It is true that the immediate prospects for imported scrap are better than they were, and that there are expectations of bigger arrivals during the summer of imported ore. But the improvement in the raw material position for steel making can be brought about only if the good beginning to the home scrap drive is kept up. The Federation and its associated organisations are now intensifying the scrap campaign. So far, that campaign has been concentrated mainly on speeding up the collection of scrap within the steel works themselves and in associated works. An excellent start has undoubtedly been made. Steel users everywhere, whether industrial undertakings, farmers or private individuals, can share in the task of ensuring that this drive for ferrous scrap continues to be increasingly successful. Scrap merchants in all parts of the country have been informed of the drive, and the district scrap committees are at all times ready to assist if any difficulties over the disposal of scrap should arise. A big steel output is essential to the nation's civil and military requirements. That output will be forthcoming if supplies of scrap are made readily and regularly available instead of being hoarded and forgotten. Scrap remains an important raw material.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BRITAIN'S FUEL POLICY

SIR,—I refer to your leader of June 1st, commenting on the reprint in the same issue of Sir Claude Gibb's recent lecture to the Yorkshire Section of the Institute of Fuel at Leeds.

There is no virtue in carbonising any more coal than is strictly necessary, since the process is extremely wasteful of fuel heat (available energy) and there is a serious loss therefore in using gas as compared with coal for electricity generation. The import of equivalent by-products when available should be judged strictly on commercial grounds, even if some uneconomic separation of by-products is justifiable for national security.

Vast additional quantities of electricity will be required in the future to drive British industry, and this can be complementary to the production of vast quantities of low-grade heat in the form of steam or hot water, which has the advantage of many times greater thermodynamic efficiency with at least equal convenience to house and factory process heating by coal, electricity or gas. By far the most efficient engine so far suggested for the purpose is a gas turbine form of engine using steam as the working fluid.

By-product and gas production, as far as it may be forced upon us, should be integrated much more closely with electric generation, and electric generation should be so sited that the waste heat from it can be used for heating of factories and domestic premises. Thus there is less than no virtue in pithead or near pithead generation unless a large population or low-grade heat-using energy is adjacent to consume the waste heat.

For a significant improvement in national fuel utilisation to take place, the whole investment policy of the fuel and power industries combined will have to be co-ordinated and the strategy drastically changed. Coal is becoming so precious that as little as possible should find its way direct into the hands of the public or small factories, whose primitive utilisation necessarily has an exceedingly poor thermodynamic efficiency. They should instead be encouraged to use communal services for heat and power so that large-scale scientific utilisation can produce vastly greater quantities of all these services from a limited coal supply.

J. F. FIELD

Edinburgh, June 9th.

132kV WOOD POLE TRANSMISSION LINE

SIR,—The short article on page 796 *ante*, on the above subject, interested me, but I was rather surprised to learn that no earth wire will be provided and the steelwork will be unearthed.

I was under the impression that the earth wire had proved most efficacious in protecting the grid lines from lightning strokes; in the event of the unearthed steelwork being struck there would appear to be a grave danger of the

wood poles being shattered by the discharge, with consequent serious damage to the transmission line and a prolonged interruption of the supply.

Doubtless the designers have thoroughly weighed these matters and presumably the additional cost of providing an earth wire has been the deciding factor, but it would be interesting to hear the views of the B.E.A. for having decided to depart from the normal practice.

J. F. PERRIN

Carlisle, June 16th.

Edmonton and Engineers

IN an editorial under this title last week an unfortunate error occurred. We wrote that the Engineers' Guild, in conjunction with the National Association of Local Government Officers, was arranging for a question to be asked in the House of Commons. In fact, the body which is operating with the Guild is the Association of Local Government Officers and Surveyors. Our apologies are due to both these bodies.

The question in the House was duly asked and received a written answer from Mr. Barnes, Minister of Transport, last Monday. He said that the appointment of a borough engineer became subject to his approval only if the council concerned sought grant from the Road Fund in respect to his salary. He was informing the Edmonton Borough Council that he would regard the requirement that candidates be members of a trade union affiliated to the Trades Union Congress as incompatible with the conditions on which he made Road Fund grants, particularly the established principle that councils should make their choice from as wide as possible a field of candidates having appropriate professional qualifications.

Lighthouse Centenary

FROM the South Bank Exhibition there shines out every night a flashing beacon. It comes from the top of the Shot Tower and the installation of the lighting and optical system was provided by Chance Brothers, Ltd. One-hundred years ago that firm exhibited at the 1851 Exhibition the very first lighthouse optic it ever produced. Indeed, this Festival year coincides with the centenary of the beginning of the manufacture of lighthouse apparatus by Chance Brothers, Ltd., at Smethwick. That firm had, of course, already been in existence for some twenty-five years by 1851 and was already well known for its glass products. It was Sir James Timmins Chance, nephew of the founder, Robert Lucas Chance, who saw the great opportunity that existed to improve navigational lighting. In 1851 tallow candles were still in occasional use as illuminants! Sir James, assisted by Dr. John Hopkinson, began to work out the technical improvements in illuminating and optical systems, which have since led to the building of "robot" lights that can now run for very long periods virtually unattended. Navigational lights by sea and air, made by Chance Brothers, Ltd., now ring the world and add immeasurably to the safety of sea and air travel.

To celebrate the occasion a dinner was recently held at the Savoy Hotel, at which Viscount Alexander of Hillsborough, Elder Brother of Trinity House, was the principal amongst a numerous array of guests. Those present were seated at tables which, instead of being numbered, bore the names of famous lighthouses and each received a menu card and toast list enclosed between coloured glass covers made by the firm and engraved with a portrait of Sir James Timmins Chance and a representation of that most fantastic of ancient lighthouses, Winstanley's Eddystone lighthouse of 1699–1703.

Exhibition of Industrial Power at Kelvin Hall

No. IV—(*Continued from page 798, June 15th*)

POWER FOR INDUSTRY

LEAVING the Hall of Steel, in which is demonstrated the progress made in the production and forming of steel, the next step in the sequence is the exhibits in Power for Industry, where the use of steel and other metals in the construction of units for the generating of industrial power is on view. Here we have exhibited the three main systems of developing the power required to drive the machinery necessary to satisfy the demand for consumer goods. Boilers of different design, supplied complete with auxiliaries by members of the Combustion Engineering Association, show the raising of steam, and a turbine rotor, together with a reciprocating compound engine illustrate the mechanical means for converting steam into horsepower. One of the latest designs of oil engine complete with turbo-chargers shows power developed using oil as fuel, and a full-scale model of a gas turbine demonstrates the latest form of prime mover.

The vertical boiler display, illustrated herewith, consists of a boiler 12ft 3in high by 5ft diameter, constructed of mild steel boiler plate and capable of producing 1250 lb of steam per hour on a coal consumption of about 18 lb per square foot per hour. Brief particulars are: heating surface, 120 square feet; grate area, 15·4 square feet; four cross tubes of 8⅝in outside diameter, and a weight of 4 tons 6 cwt, with the weight of water to working level being 31 cwt. Two pumps are included, one electrically driven and one steam driven, the former being used for starting up. Of plunger design, with a plunger having a diameter of 1in and a stroke of 3in, and a crankshaft speed of 170 r.p.m., the automatically controlled pump is driven through vee belts by a 1 h.p. electric motor running at 940 r.p.m. A float switch operated by the water level in the boiler controls the pump, and the device also controls the horizontal duplex steam pump, which has a 3in diameter steam cylinder, a 2in diameter water cylinder, and a stroke of 3in. The Underfeed stoker draws its coal from a bunker by means of a conveyor worm and a feed worm, both of heat-treated alloy steel and working in cast iron troughs. Control is by the boiler water level and also by means of a pressure start. Combustion air is supplied by a fan through a duct to the fuel bed. Operated by a multi-speed, totally enclosed gearbox driven by an electric motor, the screw can deliver up to 350 lb of coal per hour. Associated with the display is a gilled tube economiser consisting of twelve 5ft tubes, arranged three tubes wide by four high in one tier, with a by-pass flue. Gas streams pass over the heating surface without interruption and are not confined to one portion of the economiser, since all passages are communicating. Maximum working pressure is 650 lb per square inch, and performance figures are: evaporation, 1500 lb per hour; gas weight, 4200 lb per hour; gas inlet and outlet temperatures being 750 deg. and 525 deg. Fah. respectively, and the corresponding water temperatures 120 deg. and 280 deg. Fah.; fuel saving amounts to approximately 16 per cent.

The second boiler group is a full-size section of a Lancashire boiler, 9ft in diameter, together with associated auxiliaries. The exhibit is cut away to show the internal arrangement of the boiler and the working of the mechanical stoker, and the ash extractor. This design of boiler was developed mainly to meet the demand of the cotton industry, and they are built in sizes to supply steam at rates from 3000 lb to 15,000 lb per hour. A sprinkler stoker, with a forced draught grate, is fitted in which the movement of the stepped feed plate causes the fuel in the hopper to work down to a flat table surface integral with the stoker. From here it is pushed forward to fall on to a curved adjustable throw plate from where distributor blades, running at 300 to 400 r.p.m., spray it on to the fire, alternate blades scattering the fuel to right and left. To avoid injury to the mechanism, the blades are held in position by centrifugal force and any obstruction causes them to swing back on their pivot rods. A rate of feed of up to 15 cwt per hour may be obtained, and the power absorbed by a pair of units is 0·75 h.p. Complete combustion is ensured by the use of a preheated secondary air supply.

There is a superheater of pendant convection design and a section of a cast iron vertical tube economiser which consists of forty-eight 9ft tubes arranged six tubes wide in one group, a mild steel front casing and vertical and horizontal gas baffles. The economiser normally installed with a Lancashire boiler 30ft long by 9ft diameter consists of two groups of tubes and has an evaporation rate of 12,250 lb per hour, a gas weight of 26,000 lb per hour, the gas inlet and outlet temperatures being respectively 850 deg. and 557 deg. Fah., while the corresponding water temperatures are 150 deg. and 290 deg. Fah. Instrumentation consists of a vertical edgewise draught indicator giving the suction over the fire at the boiler outlet and the flow of both steam and combustion air is recorded separately in a meter in which the coincidence of the two pens indicates that the correct excess air is being supplied.

A self-contained, double-pass economic boiler, which we illustrate, is on view, in which combustion products pass from the furnace fire tubes at the rear to the combustion chamber, then through smoke tubes to the front of the boiler, thence by way of a smoke-box to the chimney. Brickwork setting is not required. Waste heat is absorbed by a cast iron economiser, which consists of twelve tubes, each 6ft 7in long, arranged four in width and three high, and having a total heating surface of 475 square feet. Both sides are provided with packed mild steel casing and swing doors at the ends give access to the return bends, while a by-pass flue permits the boiler to be operated without the economiser. The maximum working pressure is 650 lb per square inch, and straight gills on tangential plates, cast on opposite sides of the tubes, form the heating surface. Fuel is mechanically handled, the coal being raised by an elevator to the mechanical stoker, which spreads it on the grate.

Feed water pumps for both the Lancashire boiler unit and the Economic steam generator display were direct-acting pumps supplied by G. and J. Weir, Ltd.

The story of steam generation is completed by the exhibit of the Water-Tube Boilermakers' Association, consisting of a

model of a boiler unit and an animated display in colour, some 40ft in length, showing in diagrammatic form the operation of a modern pulverised-fuel-fired water-tube boiler plant.

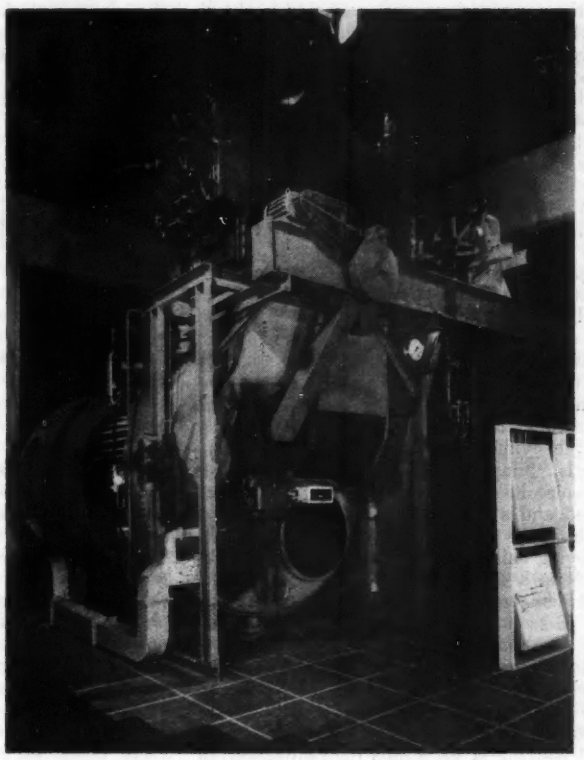
The model is on a scale of $\frac{3}{8}$in equals 1ft, and represents a boiler with a continuous rating of 200,000 lb of steam per hour at 645 lb per square inch superheated to 840 deg. Fah. from feed water at 350 deg. Fah. Fuel burning arrangements are designed to use brown coal having a 66½ per cent moisture content, a high ash content, and a calorific value, as fired, of 3710 B.Th.U. per pound. Three beater mills, each of 15 tons per hour capacity, supply the boiler. A plain steel tube economiser is included and a tubular air heater, the cold end of which is formed of corrosion-resisting cast iron tubes. Before exhausting to the stack an electrostatic precipitator extracts the fine dust. The boiler works under a system of forced and induced draught, and there are two forced draught fans, each driven by a 88 h.p. motor and rated to deliver 60,300 cubic feet per minute of air at 70 deg. Fah. at a pressure of 6·35in water gauge. The two induced draught fans can each deal with 123,600 cubic feet per minute of flue gases at 380 deg. Fah. at 12·9in water gauge, and are driven by motors of 380 h.p.

In the animated display mentioned above, distinctive colours trace the fuel, air and water-steam circuits. The flow of coal from bunker to burner is shown, as is that of the air supply from the forced draught fans, through the preheater to the primary and secondary ducting, and then the path of the gas from the combustion chamber to, in turn, the superheater, economiser, grit separator, air preheater, dust precipitator and finally through the induced draught fans to the stack. Similarly, the water supply is traced from the feed pump to the economiser and the boiler, and then, as steam, from the superheater outlet to the turbine driving an alternator. The boiler is shown having a water-lined radiant transfer combustion chamber with a bank of convection transfer tubes before the superheater.

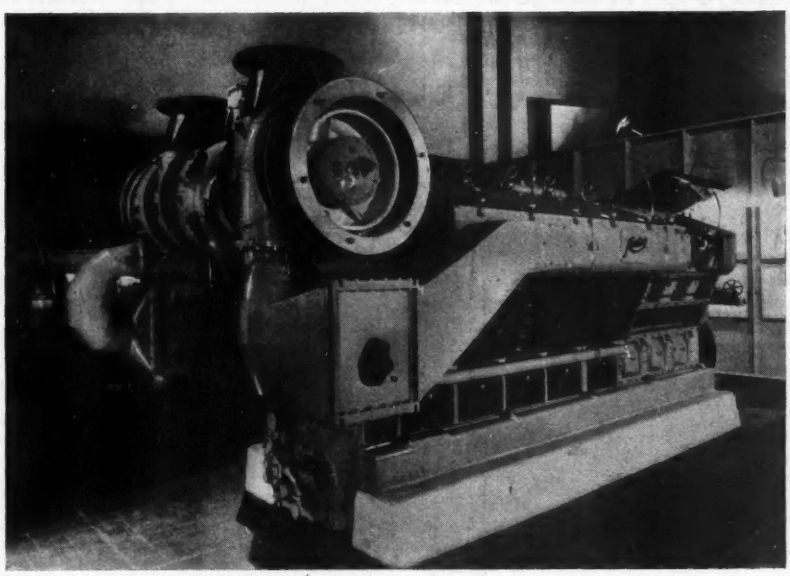
Photographs of parts of actual installations form colour transparencies, and they are illuminated by a push button which also switches on a pilot light in the diagram to indicate the position of that particular component. There are thirteen illustrations, which show a coal stock pile and transporter crane, conveyor belts and trippers, a pulverised fuel mill, a water-cooled furnace interior, the combustion chamber, superheater coils, a steam drum being forged, boiler erection, economiser, a turbo-feed pump, forced and induced draught fans, and a 60,000kW turbo-alternator.

An example of a steam-driven auxiliary is seen in the exhibit of Belliss and Morcom, Ltd. The company has on view a two-crank compound steam engine, with separate inclined piston slide valves, driving a 150kW, three-phase, 50c/s, 400V alternator manufactured by Lancashire Dynamo and Crypto Company, Ltd. The engine runs at 500 r.p.m. and is designed to operate on dry saturated steam at a pressure of 180 lb per square inch gauge with a back pressure of 5 lb per square inch gauge. In this engine the cranks are set opposite each other and steam is admitted simultaneously to the

VERTICAL BOILER



ECONOMIC BOILER



TURBO-CHARGED 2270 B.H.P. DIESEL ENGINE

top of one cylinder and the bottom of the other. The high and low-pressure slide valves are in separate chambers placed between the cylinders, and are operated radially from the shaft by separate eccentrics; the high-pressure valve cuts off on the inner edges and exhausts directly to the low-pressure, thus avoiding the use of outside receiver pipes.

The production of power from oil by use of the compression-ignition engine is shown in the high-pressure, turbo-charged oil engine illustrated on page 833 which is the latest product of Mirrlees, Bickerton and Day, Ltd. This engine has sixteen cylinders arranged in vee form and develops 2270 b.h.p. at 900 r.p.m. on a twelve-hour rating, the b.m.e.p. being 160 lb per square inch and the boost pressure 7·5 lb per square inch. Both the bed-plate and monobloc cylinder housing are fabricated from mild steel plate, the welds being stress relieved. Large inspection covers give access to the main bearings, big-end bearings, camshafts and fuel pumps. Each cast iron cylinder head is arranged with the injector spaced centrally between the two exhaust and two air inlet valves. There is also a starting non-return valve, while the cylinder liners are of chrome-hardened cast iron located firmly in the cylinder and built to expand downwards. Simple valve-operating gear, which is pressure lubricated and totally enclosed, is fitted, and is operated through push-rods from high-tensile steel ground bar camshafts carrying chill cast cam profiles. The crankshaft is a 45/50-ton steel forging hardened and tempered, while the connecting-rod is an H-section steel forging. The pistons are of aluminium alloy with a combustion chamber formed in the crown. The bore and stroke are 9¾in and 10½in respectively, and the piston speed 1578ft per second. Individual pumps supply fuel to each cylinder and starting is by means of compressed air at a nominal pressure of 300 lb per square inch. The brake thermal efficiency is 38 per cent and the dry weight of the engine is 17·2 tons.

A full-scale sectional model of the Ruston and Hornsby industrial gas turbine driving a 750kW alternator is shown, accompanied by a diagram which explains the working cycle and gives temperatures and pressures. The exhibit, which we illustrate, demonstrates the form and development of the gas turbine for industrial power. Preliminary design work was begun in 1946 and the turbine was first run under its own power in 1949. Endurance tests complete with the alternator were finished late in 1950. The set is constructed in four major units, connected by flexible ducts; there is a gas generator unit, consisting of a two-stage, high-pressure turbine driving a thirteen-stage, axial-flow compressor; a heat exchanger flexibly supported from the main turbine frame; combustion chambers arranged symmetrically one on each side of the plant, and the combined power turbine and reduction gear. Any one section can be dismantled without interfering with the other parts.

There are a number of interesting details in the design of the turbine; a cooled stator with segmental shrouding is used for the compressor driving turbine, and two-stage overhung disc turbine rotors are used for both the turbine driving the compressor and the output turbine. Other noteworthy points are the use of thin-section, high-temperature ducting supported kinematically within an external pressure-carrying casing, and the employment of an epicyclic reduction gear. The overall performance of the complete unit on full load showed that the fuel consumption was 0·59 lb per brake horse-power per hour, and that the thermal efficiency reached 23·4 per cent.

(To be continued)

MODEL OF 750KW GAS TURBINE

The Iron and Steel Institute

No. III—*(Continued from page 788, June 15th)*

ABSTRACTS of the discussion of Dr. J. B. Austins' paper entitled "Significance of Equilibrium and Reaction Rate in the Blast Furnace Process," which was delivered on the afternoon of Wednesday, May 30th, are continued below.

Mr. H. D. Ward (B.I.S.R.A.): As Dr. Saunders has already said, the subject of tuyere photography has recently received study by the B.I.S.R.A., and I should like to describe briefly the work which has been carried out. The approach has been to find the best system by which the size of an object photographed can be measured, and its position in space determined, in spite of the fact that there is some 8ft between the camera at the tuyere latch and the end of the tuyere nose.

Using a simple photograph taken with small depth of focus, any object which is in focus would necessarily be at the predetermined focal distance and can be dimensioned. If the depth of focus is great, the distance of the object is not known and it cannot be measured precisely. In considering the depth of focus we use the quantity known as the hyperfocal distance of the camera lens. By calculation and approximation we find that, within 1 per cent, the total range in focus equals $2d^2/10^3S$, where d is the distance from the camera to the object and S is the iris diameter. All these dimensions are in inches. This result is interesting in that it is independent of numerical aperture or "f" number and depends only on the iris diameter of the lens and the distance of the object from the camera.

Several values have been calculated, a few of which I should like to quote:

Lens diameter, in	Distance of object, ft	Total focal depth, in
1	1	0·29
1	10	28·8
2	10	14·4
5	10	5·76

It would thus appear that, in order to obtain reasonable accuracy, a lens of 5in diameter is required. The provision of a 5in diameter viewing hole in the tuyere door, however, was not considered to be a practical proposition, due to the dangerous conditions which would arise in the event of slag entering the tuyere. Accordingly, an alternative method of approach was examined, namely, the use of stereoscopic photography. (Mr. Ward then illustrated, by slides, the stereoscopic photography method.)

Mr. R. P. Towndrow (Colvilles, Ltd.): The author has shown us a study of a portion of the slag-metal sulphur equilibrium, and he talks about sulphur from 0·03 per cent down to 0·02 per cent. The average blast-furnace manager in this country would be very pleased if he could get the sulphur down to 0·03 per cent, and would not worry about getting down to 0·02 per cent. One of our difficulties is that when we put down a large number of ratios of slag sulphur to metal sulphur from casts which are ostensibly made under similar conditions of slag basicity, temperature, smoothness of furnace operation and other things which we think influence desulphurisation, we get very varying values for the ratio between the sulphur in the slag and the sulphur in the iron. Most of us are very good at drawing plots on paper, and we draw lines between sulphur and silicon and get the usual spotty affair, and we try to pick out groups where the silicon figures are all the same and get another spotty affair of a somewhat different shape. If we are very brave we may try to make three-dimensional models, but we still get the spots randomly distributed. We then remember that we have forgotten the manganese and try to bring that in as well.

In the blast-furnace we are not dealing with a simple equilibrium between a bath of iron and a bath of slag; all sorts of other factors influence it, and particularly the conditions of oxidation or reduction which are prevalent in the space immediately in front of the tuyeres. It seems to me that a great deal of profitable information could

be gained if we could tie up some of the things which happen in the upper part of the curve, because, in spite of the author's experiments showing that in the cases investigated the approach to equilibrium was very close, I think that those of us who have dealt with it less scientifically, but in greater bulk, are not by any means so satisfied that that equilibrium is attained, and we want to know why it is not and what we can do to make it more readily attainable.

Dr. T. P. Colclough (British Iron and Steel Federation): One point which I should like to emphasise in this discussion is that there is no such thing as an equilibrium in blast-furnace operation. The equilibrium must be related to a temperature. We have done a good deal in the last twenty years to approach the equilibrium for 650 deg. Cent., which I reckon is 1/1, or for practical uses 1·2/1, and at the International Foundry Congress in Amsterdam last year I presented a paper indicating what sort of coke consumption one ought to have under blast-furnace operation for that purpose.

One factor not yet emphasised at all sufficiently is the blast-furnace technical operator. Taking the tuyere and the "balloon," or whatever one likes to call it, and the air space for burning the oxygen, as the ogyxen goes in there it must go to CO; it cannot go to anything else. If we are to have, higher up, that CO turned into a CO/CO_2 ratio of 1/1, instead of 1,000,000/1, the only one way in which it can be done is by supplying that uprising stream of gas with oxygen, and that oxygen can come only from iron oxide. Before, therefore, it is possible to attain equilibrium, no matter whether you fix it at 1/1 or 2/1 or 10/1, the operator must calculate how much oxygen he is going to supply in the form of ore in order to attain it.

Dr. F. D. Richardson (Nuffield Research Group in Extraction Metallurgy, Royal School of Mines): About a year ago Mr. Jeffs and I made a thermodynamic assessment of what might go on inside the blast-furnace, and, on purely thermodynamic reasoning, we came to the conclusion that between slag and metal in ordinary blast-furnace practice in this country we were well out of equilibrium with respect to sulphur, the slag not having anything like enough, and probably a little out of equilibrium with respect to silicon, the metal having too little silicon, and also too little manganese. That was borne out by the work of Hatch and Chipman on the partition of sulphur under laboratory conditions, and also by the work that the present author has reported.

If slag and metal are as far out of equilibrium with respect to sulphur as this work suggests, then the possibility suggests itself of doing a ladle desulphurisation of blast-furnace metal with blast-furnace slag in a carbon-lined ladle—something akin to the carbonate desulphurisation, but with materials which are to hand, already hot, and materials which may not be so objectionable. With regard to the mechanism, I should like to ask whether it is the author's view that the reason that we do not get equilibrium from the very rapid reaction between slag and metal is not that the reaction is actually at the interface, but that it is a slow business getting the reactants and resultants away from this interface and back and forth to and from it; in other words, it is diffusion in the liquid system which is really the controlling factor.

Dr. I. T. J. Irvine (University of Leeds): The author brings out very clearly that with lake ore practice the amount of carbon is governed by the requirement of carbon as a reducing agent, and therefore the conclusion can be drawn that such work as ore sizing, elimination of fines and high-pressure operation will be of more immediate concern than such improvements as oxygenation of the blast and high blast temperature. Those conclusions are supported in the paper, and also in the paper by Mr. Rice. If this is the case, it is desirable that the maximum amount of information should be obtained about the actual conditions in the reduction zone. With regard to such factors as structure of the ore, porosity, rate of reducibility, and so on, some information can be obtained by work outside the furnace, in the laboratory; but with regard to the actual reactions, efficiency of gas-sold contact and so on, it is much more difficult, and in that respect it seems to me that one of the most valuable indications which can be obtained has largely been ignored; I refer to the composition of the gas which comes out of the furnace.

Dr. S. Klemantaski (Imperial College): The author's broad survey refers only briefly to carbon deposition, and that mainly from the point of view of its effect on refractories; yet it seems likely that carbon deposition has an important influence on the blast-furnace process, not only through its well-known effect of disrupting the ore and causing swelling of the burden, but also by modifying the balance between indirect and direct reduction.

This opinion is partly based on our experimental work (now being prepared for publication) on ore reduction with CO containing inhibitors of carbon deposition. It was found that the rate of low-temperature reduction could be greatly increased by stopping carbon deposition. We are, of course, aware that conditions in the blast-furnace are not those of the laboratory; but these results do suggest that, by hindering ore reduction in the upper part of the furnace, carbon deposition increases the concentration of oxygen in the lower part. Because of the deposited carbon, the carbon concentration is also increased in the lower part of the furnace. The combination of these two factors—increased concentrations of oxygen and of carbon in a suitable temperature zone—must tend to favour direct reduction. I venture to suggest that if the early proposal of the Bone-Saunders school, that ores should be assessed for their effect on carbon deposition as well as their reducibility, had been followed up, our control and understanding of the blast-furnace process might be better.

On Thursday morning, May 31st, there was a joint discussion on the following three papers:—

"SOME ASPECTS OF THE BLAST FURNACE SITUATION IN THE UNITED STATES,"

By Owen R. Rice

Synopsis

The centre of focus of the American blast furnace picture to-day is massive production. Iron is in great demand, whether as cold pig or as hot metal. Nine new blast furnace units are being erected and at least six more are under serious projection. Many small furnaces are being enlarged within the limits of standing steelwork. The statement that all of the 247 American blast furnaces are in commission leads to the "searching of the haystack and to the finding of a needle or two," symbolising just about that number of units whose prolonged inactivity is accounted for by peculiar commercial or logistic situations. Furnaces are being pushed to the maximum rate compatible with quality of product and rational operational behaviour. In planetary arrangement around this central sun of high production and contributing to its eminence, are such factors as increased devotion to the beneficiation of raw materials; improvements in materials for linings, which reduce the frequency of furnace rehabilitation; exploration of technological innovations; employment of ever-better design, construction and necessary equipment, and the employment of more technicians and metallurgical assistants.

THE EVOLUTION OF THE ALL-CARBON BLAST-FURNACE

By J. H. Chesters, G. D. Elliot, and J. Mackenzie

Synopsis

The use of carbon bricks in the blast-furnace is traced from the early hearth experiments, designed to minimise breakouts, to the present stage of three all-carbon blast-furnaces at Appleby-Frodingham. The properties of carbon bricks and the essential design features of carbon hearths are discussed in detail. It is concluded from operating evidence and from the results of examination of blown-out hearths that carbon is successful in preventing breakouts.

Trials of carbon bricks in bosh and stack are described with particular reference to scaffold formation. Operation and cost details of No. 6 furnace, Appleby-Frodingham, which was built as the first blast-furnace in the world completely lined in carbon and was blown-in in April, 1949, and of No. 1 and No. 5 furnaces, which were later relined in carbon and blown-in in October, 1949, and April, 1950, respectively, are discussed. In spite of burden handicaps, in the first year of operation No. 6 furnace made 12 per cent and No. 1 furnace 4 per cent, more iron than in the first year of the previous campaigns.

RADIOACTIVE INDICATORS FOR BLAST-FURNACE REFRACTORY WEAR

By E. W. Voice, B.Sc., A.Inst.P.

Synopsis

Some isotopes emit strongly penetrating gamma radiations, which can be detected through 2ft or 3ft of firebrick. This property may be used to give evidence of blast-furnace refractory wear, and details of the method are given.

Discussion

Mr. R. P. Towndrow (Colvilles, Ltd): Most of us have been familiar for a long time with the Rice formula for the rating of a blast-furnace and have tried to fit our own data into that conception. In British furnace practice not only does the average rating fall far below that of its American counterpart, but the rate also varies very considerably from district to district in Britain. Mr. Rice draws a very sharp distinction between Southern and Northern operation in the U.S.A., and we appreciate the reasons for this simplification. In British practice, however, we cannot make such a simple classification. The range of difference is equally marked, but the number of stages in between is very considerably more varied. Even those of us who ostensibly are using imported ores find ourselves to-day making up to 30 per cent of our iron from a most wonderful assortment of odds and ends which probably no American furnace operator would condescend to put in his stockyard at all.

In the case of those of our furnaces which compare to some extent with the Southern furnaces of the United States—that is to say, those working on lean ores—I think there will be general agreement that a very early limitation to the rate of blowing exists in the high volumetric ratio of ore to coke and in the difficulty of screening out the fines efficiently from the burden. These factors impose limits on the rate at which we can blow the furnace without giving rise to irregular stock movement and high flue dust loss. Under our conditions of operation we have tended to believe that an undue sacrifice to smooth furnace operation does not pay dividends in terms of coke rate, lining life and ultimate profits. At the other end of the scale, I believe that the reasons for our more conservative blowing rates are quite different. There appears to be little physical reason, in furnaces working on a reasonably screened burden of rich ores, why the blowing rate should not be very much higher than it currently is. However, although we can make our furnaces drive smoothly under those conditions, at high blowing rates we

find that where the burden consists largely of dense magnetite ores we get an unduly high coke rate.

I should like to confirm what Mr. Rice says about the need for technical operators on the blast-furnace. This is a subject on which I have had many arguments with my colleagues. There is no doubt that it is difficult to find the right kind of technician who will stay the course. We want him to operate the furnace on shifts, but he wants to be on the day shift, and there are not so many jobs on the day shift in any case. If we are to get the utmost out of the technical knowledge that we have gained and out of our technical equipment, we must have technical operators on the rotating shift as well as on the day shift. The separation of brains and brawn has to cease. It is a question of getting the right balance between them and of seeing that it is applied in the right place.

Mr. G. D. Elliot (Appleby-Frodingham Steel Company): Mr. Rice has achieved fame for the Rice formula. I agree that it can be, and is, a very handy yardstick of day-to-day operation, but there are many factors which must be considered when we are discussing the Rice rating. If we look at Fig. 2 of his paper, there are three Dutch furnaces which stand out as being in excess of the rating, and we see that all the English furnaces are below rating. If we turn to Table III we see that the Dutch furnaces have the highest coke rate of any given in the table. We see also that the average British furnace has the same coke rate as the average United States furnace, but the slag volume in Britain is higher than in the U.S.A. I submit, therefore, that coke consumption per ton of pig and slag volume per ton of pig have an effect on rating. After all, we can burn coke only at the speed at which we can push air through the bed of coke, and high slag volume must have a bearing there. Similarly, I believe that the low bulk density of British native ores affects the ease or otherwise of achieving the Rice rating.

Mr. A. T. Ledgard (Dorman Long and Co., Ltd.): In his introduction Mr. Rice says that the centre of focus of the American blast-furnace picture to-day is massive production. In England I think that we could very safely say that the centre of focus is not massive production, but rigid economy. I think that we are more concerned with the coke consumption than we are with the final total output of iron.

With regard to maximum blowing rates, I think that the Americans achieve 100 per cent efficiency with their blowing rates more by carrying low blast temperatures than by just blowing the wind into the furnace. A furnace foreman in this country, if the furnace is hanging, will say: "What shall we do? Shall we take the blast down 3000 or 4000 cubic feet or reduce the blast temperature?" The same result is obtained by lowering the blast volume as by reducing the blast temperature; the furnace will probably come away and work freely in either case. If we reduced the blast temperature from the normal 1250 deg. Fah. to the American standard of 1000 deg. Fah., I think that whereas normally we should blow about 33,000 to 35,000 cubic feet per minute on an 18ft 6in or 18ft furnace, we could quite safely carry at least 3000, 4000 or even 5000 cubic feet of blast more per minute. This would mean that whereas normally we should be carrying something like a 75 per cent rating, we could probably get up to 90 per cent, but it would be at the expense of coke consumption.

Mr. J. M. Ridgeon (B.I.S.R.A.): My particular interest is this question of the Rice index in the rating of furnaces. I have made use of this index in plotting a considerable amount of British blast-furnace data over a number of years, and Mr. Rice's Fig. 2 is no surprise to me. I remember plotting a very large collection of British data relating to periods of record operation. We managed to get the four-week period when the various furnaces had burnt more coke than in any other comparable period, and on the whole the plot which they gave on the Rice rating formula was very similar to the plot which the American furnaces give, except, of course, that they did not extend up to such large hearth diameters. I have similarly plotted data extending over fairly long periods. I have recently collected data for about twenty furnaces for 1950 and have plotted those on Fig. 2 in Mr. Rice's paper, and they agree very closely with the rather smaller number of points which Mr. Rice has shown for British practice, so that there is undoubtedly a case to answer. It is also interesting to note that in one of the tests on the No. 10 furnace at Appleby-Frodingham there is a test period when a 92 per cent rating was reached.

I find it very instructive, in studying this problem, to consider the various types of interrelationships which occur between blast-furnace variables. This has arisen particularly in statistical studies when comparing one variable with another. One often gets into a mental fog as to which is the dependent variable and which is the independent variable. I have chosen a rather crude case to refer to here, namely, the coke rate per ton of pig. One naturally considers that as a dependent variable, depending on the iron content of the burden, slag volume, blast temperature, coke quality, and so on, but it can be argued that the coke rate can be regarded as an independent variable, influencing other things, because it is the furnace manager who decides what the coke rate is to be. The coke rate is the amount of coke put in at the top per unit of iron, and here the major dependent variable would appear to be whether the furnace will work or whether it will not. When, however, one considers Southern practice in the U.S.A., one feels that the right phrase might be "How will the furnace work under the conditions imposed?" which is a very different thing. I have always taken the view that the iron output should be looked upon as a ratio of the coke burnt to the coke rate, and in investigating the effect of any variables on output it is profitable to state the effect of those variables on the coke rate and the coke burnt, and not try to correlate them directly.

Dr. J. H. Chesters (United Steel Companies, Ltd.): Mr. Rice is right in praising American alumina-silicate refractories. We have had an opportunity of testing some of them and they are unique. They have extraordinarily low porosity, are very hard burnt and are volume stable. I must, however, question Mr. Rice's statement that because a brick shows a positive expansion in an A.S.T.M. reheat test it is necessarily permanently free from shrinkage in a furnace hearth. We have yet to find any alumina-silicate brick which will not shrink, given time.

The other point that I must question is his statement that if we can convert the iron in a firebrick for use in the stack, for example, to ferrous silicate, it will have permanent resistance to CO. We have definite information that a brick which is stable in the ordinary CO test because the iron is there as silicate can readily be made to become active to carbon deposition simply by heat-treatment at a temperature round about 1000 deg. Cent.

Finally, I should like to refer to Mr. Rice's mention of pelletising. He quotes *Iron Age* in saying that this is harder than was supposed, and that may deter some people in this country from studying it. During my recent visit to the United States I was more impressed by what the Americans are doing in regard to this type of treatment of iron ores and concentration than by anything else that I saw, and I feel that we have an enormous amount to learn from it. To be able to take an ore such as taconite, a hard ore, and separate the magnetite and silica by grinding to 300 mesh and put it together by pelletising, and to do that at a price which may be competitive with foreign ores, is no mean achievement. I believe that by studying these techniques, and I emphasise the techniques and not the particular processes, the methods used in the laboratory for studying ores and the comparative data built up and the fundamental attack, and by applying them to our very peculiar and worse ores, we shall gain very considerably.

Mr. E. W. Voice (B.I.S.R.A.): I propose to limit my remarks to the paper on the carbon furnace by Chesters, Elliot and Mackenzie. The authors emphasise the importance of carbon having a high thermal conductivity and realise that molten metal would be expected to penetrate lower down a carbon hearth than a firebrick hearth. We have set ourselves the problem of calculating the temperature distribution underneath a blast-furnace hearth, and the results indicate that there is little temperature drop through the carbon, and molten metal may easily get below it. On one large furnace a thermocouple was installed in the fabric 8ft below the base of the 4½ft of carbon. The calculated temperature was 550 deg. Cent. and the actual temperature 520 deg. Cent. After six months, when the furnace was nearly heated up, the temperature at the base of the carbon was found to be 1300 deg. Cent., and there would therefore be considerable mechanical upthrust due to many blocks being surrounded by molten metal. In some designs high temperatures can penetrate to the concrete foundations, and this may cause damage.

It has already been suggested that the carbon hearth should be cooled, and the emphasis is on air cooling, so as to have a safe method which will be acceptable to the operator. Calculations of the air flow required suggest that the fan power and complications are very small. To preserve a carbon hearth for a furnace campaign a first requirement would be to exercise thermal control below the hearth, and if then the iron does not attack the carbon the hearth should last a long time. The authors' slides show that there is a considerable chance that carbon may be a suitable material from the point of view of iron attack.

Mr. C. Danielsson (Domnarvet Iron and Steel Co., Sweden): At Domnarvet we have comparatively small furnaces of about 50ft working head and a hearth diameter of about 11½ft. The furnaces are making basic Bessemer pig iron with about 0·25, 0·30 and 0·40 per cent silicon and 1·8 per cent phosphorus. The coke consumption is 65 per cent, or 13 cwt per net ton, and the daily average output over fourteen days is 295–300 tons. That means that we have a coke rate of about 75 per cent, according to what Mr. Rice says, but we also have a coke consumption of about 75 per cent of what is generally stated here. If we try to increase the production it is the sulphur in the pig iron which is the limiting factor.

With regard to carbon bottoms in blast-furnaces, I would point out that it is natural to use a cooled bottom in every electric pig

iron smelting furnace in the world, so why not in a blast-furnace of the normal type? The paper by Chesters, Elliot and Mackenzie is of the utmost interest to us in Sweden, because the use of carbon bricks in positions higher than the bosh must give us very great advantages. A main point which must be taken into consideration, however, is the durability of the carbon lining.

Dr. T. P. Colclough (British Iron and Steel Federation): With regard to pressure, I think that Mr. Rice is absolutely right in his diagnosis. We in Britain do not blow our blast-furnaces as we ought to do. When we came into the period of turbo-blowers, I think I am right in saying that most of the turbo-blowers were designed with a maximum operating rating of about 20 lb per square inch. That is obviously not enough. It was enough for the conditions in Britain, with an average of about 12 lb. The new blowers, however, are being designed for 30 lb pressure, following the lead which I think was given by Ingersoll-Rand in America in the early 'thirties. The changing over of blowing capacity on blast-furnaces is a very big job, but I think I can assure Mr. Rice that that procedure is well in hand, and that all the new blowers which are being installed will have ample capacity. From that point of view the question of pressurised blowing is important, and if it only directs attention to the desirability of having further blowing power behind us it will serve a useful purpose.

(To be continued)

Joint Engineering Conference

No. III—*(Continued from page 800, June 15th)*

WE continue below our summaries of papers presented at the Joint Engineering Conference in London, which ended on Friday last, June 15th.

Monday, June 11th

DEVELOPMENT AND DESIGN OF AIRCRAFT STRUCTURES

By Professor A. G. Pugsley, M.I.C.E.

PLANNING AND CONSTRUCTION OF AIRFIELDS

By J. A. Dawson, C.B.E., M.I.C.E.

Developments in British aeronautics since World War II have brought design into an unusually marked transition stage. Until 1950, for example, a lay visitor to the annual show of the Society of British Aircraft Constructors would have found that this was very similar to its predecessors, but in 1950 aviation seemed to have taken a new lease of life. New designs of all sorts were in the air. Materials of construction of these new aeroplanes show many new features. Spar booms and extruded section stringers have in many cases moved from copper-aluminium alloys to zinc-aluminium alloys with higher tensile strength.

An aspect of military work, notably the development of the "V1" and "V2" classes introduced by the Germans in 1944, will no doubt emphasise the separation of the lines of military and civil development. This may have the effect of freeing civil aviation from being so tied to the apron strings of military needs. Thus, with the demand for large moderate-speed bombers gone, the natural advantages of flying boats may be once again canvassed. And the inability of civil aviation to pay for expensive research may tend to the steady development of existing conventional types rather than to trials of relatively extravagant experimental types.

In dealing with airfields, Mr. Dawson brings out the interesting point that during the last war about 450 airfields with hard runways were constructed for the Royal Air Force in Great Britain. It is worthy of note, however, that several grass airfields on sites where the natural drainage was excellent stood up to moderately heavy use throughout the greater part of the war.

It is generally believed to-day that for parallel runways used for landing in conditions of low visibility much greater separation than was previously considered necessary may be essential at civil airports, and that therefore the use of parallel runways on the same site for this purpose may not be practicable. The decision announced in 1950 to complete the lay-out of London Airport by the construction of two runways at an angle of about 10 deg. to the main east-west runways, instead of repeating the triangular pattern of the existing lay-out as originally proposed, appears to be indicative of this change of view. The increased use of jet aircraft is likely to bring in its train new problems in connection with the surface treatment of runways and tracks.

BRITISH MECHANICAL ROAD TRANSPORT VEHICLES: 1851–1951

By J. Shearman, M.I.Mech.E., and B. B. Winter, M.I.Mech.E.

The use of mechanical road vehicles in this country was severely restricted by law throughout the latter half of last century and was confined to steam traction engines and a few private steam carriages. On November 14, 1896, it became legal to run on the highway "locomotives" under 3 tons in weight, but with a man preceding them on foot! By the end of 1897 less than fifty motor-cars had been produced, but the young British motor industry grew from the small-scale experiments of a few men of high technical ability, the well-established cycle manufacturers, and companies specially formed to build from foreign designs, but without experience or trained staff. The Daimler-Panhard influence soon began to indicate a standard lay-out of vertical engine under a bonnet in front, open-cone clutch and sliding-change gear wheels. The first English Daimler car was completed on these lines in mid-1897 with a 4 h.p. vertical twin-cylinder engine, tube ignition, atmospheric inlet valves, tiller steering, rectangular frame of wood and channel iron, solid tyres. The maximum speed was 12½ miles an hour with the engine running at 700 r.p.m. when the governor cut out the exhaust valves! Three hundred of these cars were delivered by the end of 1901.

After World War I the popular car came into being, and the Morris concern produced 35,000 of them in 1924, the year which saw the beginning of a steep fall in retail car prices. The 7 h.p. Austin, designed to provide cheap and useful family transport, achieved an international reputation. First production models in 1922 had a four-cylinder engine of 10·5 h.p., four-wheel brakes and an open body.

From 1925 to 1939 designers concentrated on production for the home market, and from 1945 to the present year there has been an intensive effort to meet worldwide requirements; the incentive thus provided has helped progress considerably. Great advances have been made on the technical side, and science in many forms has been applied with the objective of securing optimum results in minimum time, so that the old doctrine of trial and error has been largely superseded. In 1923 a research station was formed under the auspices of the Institution of Automobile Engineers, and after World War II this became the Motor Industry Research Association, which now enjoys the support of the industry as a whole; it has expanded its scope by the addition of a proving ground and is planning to expand its laboratories.

Tuesday, June 12th

RADIO MASTS AND TOWERS

By C. O. Boyse, M.I.C.E., M.I.Mech.E.

There must obviously be close collaboration between the radio engineer, who is able to state the required physical antenna properties, and the structural engineer, who seeks to achieve the desired result or the best economic compromise. From the days when Marconi conducted his early experiments, using kites to support long trailing-wire aerials, the shape and form of aerials have varied over the years to meet changing needs corresponding to advancement in radio technique and knowledge.

As the demand for long-range communications grew, the ability to direct high-frequency waves into narrow beams brought them into increasing use, thus greatly reducing the amount of transmitter power required to reach a distant point. A suitable aerial for broadcasting in this wave range was found to comprise a number of horizontal dipoles stacked in the form of a curtain of wires about two wavelengths wide and two wavelengths high. These arrays require groups of masts of medium height, relatively inexpensive, but capable of withstanding head loads of the order of 5 tons. The masts are placed so that the aerial arrays which they support are directed towards the country it is intended to serve, and one transmitter is often required to feed into a number of different arrays at different times of the day.

For television and certain radio communication systems requiring a fairly wide frequency band in which to operate, transmission at still higher frequencies became necessary. In this case energy is radiated rather like a beam of light, and the limit at which a reliable signal will be received is very approximately the visual horizon of the aerials. Consequently, although the aerials required are quite small, their height above the ground is of paramount importance, especially in the case of television signals intended to reach as many receivers as possible.

An outstanding achievement was the G.P.O.'s low-frequency station at Rugby, built in 1923 to provide a worldwide radio-telegraph communication service. The 820ft high masts are still the highest in this country and there are twelve of them altogether; eight, spaced 440 yards apart, form the corners of an irregular octagon and support between mast heads a series of horizontal "sausage" aerials. The masts were designed for a head load of 10 tons and aerial tensions are limited by the attachment of spring-loaded friction slipping devices to halyard winding drums, the springs being set to pay out aerial halyard when the tension exceeds 10 tons. Mast base and stays are insulated. The author thinks that there is nothing to suggest at present that radio structures are likely to undergo any major change in form in the immediate future.

ROAD PLANNING AND SAFETY

By G. T. Bennett, M.I.C.E.

Total traffic on British roads has once more reached pre-war figures, with less private car traffic owing to restrictions on car sales, but with a great increase in commercial traffic. New and onerous taxes have been levied upon motor vehicles and petrol sales, and the special taxation on motor transport now approximates to £250 million a year. Total expenditure on the roads is about £50 million a year, the balance being a subsidy to other purposes of the State. Mr. Bennett asks what are the reasons for treating this valuable industry in such a manner, since it is made to disgorge £200 million a year and is still expected to flourish and increase itself while every artificial attempt to crush it fails?

He believes that the answer to this lies much deeper than mere economics and the rivalry of railways. The Treasury receives the income, and the small fraction of it which it returns to the Road Fund is regarded as a burden. It would prefer to return none, but then there might be no roads and no income! It is an inviolate principle of Government finance that taxes raised on any industry for general purposes shall not be compared with expenditure on that industry. But if the expenditure

were £250 million and the income were £50 million, Mr. Bennett asks if this comparison would be so hastily brushed aside.

Neither is there any official recognition that better roads must save life and avert injury in both the humane and economic senses. Professor J. H. Jones estimated that the total cost to the counry of road accidents amounted to about £100 million in 1946. Moreover, economic loss from traffic delays is much greater than this. Mr. Bennett states that this is improvidence and therefore deplorable.

He proposes that the main centres of population should be connected by new dual carriageway roads, well aligned, safe and fast, reserved for motor vehicles only, probably between 2000 and 3000 miles in length. Finally, he points out that Great Britain largely depends for her prosperity upon exploitation of her geographical position, the short distance between ports and industrial centres favouring entrepot trade and exports, and that inland transport still represents a high proportion of the cost of goods supplied and services rendered. He therefore strongly advocates capital investment on roads in order to cheapen production costs.

FORTY YEARS' PROGRESS IN AIR RADIO

By Air Commodore C. S. Cadell, C.B.E., M.I.Mech.E., and B. J. O'Kane, A.M.I.E.E.

In the early days of flying, air-ground wireless telegraphy was soon in demand for reconnaissance work, transmissions being by spark transmitter. The Royal Naval Air Service developed two-way telegraphy and by the end of World War I all long-range aircraft were normally fitted with two-way wireless telegraphy on medium frequencies. The need for directing fighters for home defence purposes was already apparent at that time, and a successful demonstration of radio-telephony between ground and air took place before Lord Kitchener in 1915.

Direction finding also became very important during this period, and plans for a chain of direction finding stations using the Bellini-Tosi method intended mainly for plotting enemy submarines had been worked out in 1915. At the end of World War II it was not uncommon for a heavy bomber to carry several alternative means of navigation of various kinds; as more radio aids were adopted the old ones were generally retained.

Perhaps the most striking change in radio technique is the introduction of miniaturised equipment, which considerably reduces the volume and weight of individual units, thereby offsetting to some extent the increasing number of units required to meet the needs of present-day air traffic control.

In some parts of the world there may be considerable air traffic in the neighbourhood of an airport, but the nature of the surrounding territory may preclude the installation of remote navigational aids or ground radar equipment. In such cases one solution would appear to be the installation of high-power surveillance and height-finding ground radar equipment close to the airport, together with a very high frequency direction finder for identifying aircraft not carrying a transponder.

Whatever system of air traffic control is adopted, speed of communication will be essential, not only for air-ground signalling, but for point-to-point working as well. The speed of V.H.F. air-ground communication in this country is assured by the Ministry of Civil Aviation's multi-carrier scheme. In the same way, information from remote radar stations will require to be relayed in certain cases. The authors anticipate that a lightweight teleprinter may be expected to appear in very large aircraft, particularly where telegraph services for passengers are provided. Long-range navigational aids and landing aids will also be required. There is still much to be learnt about the upper atmosphere, especially by more extensive measurement of air currents at heights of 40,000ft and above, when the prediction of upper winds will improve.

Wednesday, June 13th

PRACTICAL TRAINING OF CIVIL ENGINEERS

By H. J. B. Harding, M.I.C.E.

PRACTICAL TRAINING OF MECHANICAL AND ELECTRICAL ENGINEERS

By Sir Arthur P. M. Fleming, C.B.E., M.I.Mech.E., Past-President, I.E.E.

Owing to the wide field which can be covered by a civil engineer, his practical training never ends, but the first few years are vital and affect his whole career and development. There are the consulting engineers, original leaders of the profession, concerned with reports on problems, designing works and supervising their construction, and often acting as arbitrator between client and contractor. Then there are contractors, small and large, some merging into builders, others with large staffs. Both these groups, which frequently work together, are now outnumbered by members of the Institution of Civil Engineers in Government, municipal or nationalised industrial employment.

No civil engineer is really worthy of the name unless he has had some personal experience in actual construction of works. The Institution of Civil Engineers lays stress on this in its conditions for associate membership. However high the academic qualifications, the aspiring member cannot even be considered for election unless he can give proof that he has spent at least one year in an engineering office and one year or more on works. Dealing with training problems, Mr. Harding points out that there are grave difficulties in finding employment for part-time pupils close to their centres of study. It is suggested that Government Departments employing research men should take a lesson from the Army officer scheme and attach men to firms to gain practical training and then let them return to research work.

Sir Arthur Fleming shows how part-time further education, traditional in the British system for more than 100 years, has been strengthened by the growing custom for employers to release apprentices and other young workers from work for attendance at part-time classes. Up to World War I such release was not widespread, but in 1939 38,000 young people were having that advantage, and in 1949 about 300,000 young workers in industry and commerce were attending part-time day classes.

The university course provides a fuller education in scientific and engineering principles, but the longer period of practical training of the student apprenticeship course has the advantage of providing a more extensive acquaintance with practical engineering problems. Men of both types are needed by the engineering industry, and both have equal opportunities for advancement to positions of senior responsibility. The "sandwich" course is a compromise between the "graduate" and "student" apprenticeships. To-day comparatively few young men follow this course, and the Councils of the three Institutions believe that facilities for such courses should be granted.

DEVELOPMENT AND TREND OF UNIVERSITY EDUCATION IN ENGINEERING

By Professor J. F. Baker, M.I.C.E.

THE CONTRIBUTION OF THE BRITISH TECHNICAL COLLEGES TO ENGINEERING EDUCATION

By H. L. Haslegrave, M.I.Mech.E., M.I.E.E.

"I am not an advocate for frequent changes in laws and constitutions, but laws and institutions must go hand in hand with the progress of the human mind. As that becomes more developed, more enlightened, as new discoveries are made, new truths discovered and manners and opinions change, with the change of circumstances, institutions must advance also to keep pace with the times. We might as well require a man to wear still the coat which fitted him when a boy as civilised society to remain ever under the regimen of their barbarous ancestors." These words of Thomas Jefferson, third President of the United States, have been quoted by Mr. Haslegrave to illustrate the position of the technical institutions of this country at present. He suggests means for improving educational facilities in technical colleges to meet in some way the change of circumstances brought about in both industry and in the people of our country.

Professor Baker points out that there has been little instruction in engineering above the undergraduate level, the only widespread post-graduate activity having been the training of research workers. The teaching of engineering presents peculiar difficulties because it is essentially an applied science; whilst the fundamentals must be sound, practice can never be ignored. Universities are free to decide what shall be taught, but in their engineering courses they appear to have been unduly influenced from outside. The Professor rightly points out that every far-seeing engineer in industry, in the professional institutions and in the universities has done his utmost to promote the application of science to engineering problems through theoretical training of the industry's recruits.

By 1931 the problem appeared in another form; industry accepted the graduate but did not know how to use him. That wise and witty man, Professor Inglis, wrote: "Firms are continually asking for young men of exceptional ability; but, having got them, not infrequently, they have not the foggiest notion how they should be employed. Razors are poor instruments for cutting bricks, and a chisel, if used as a screwdriver, is apt to lose its edge."

The universities have a responsibility, though not to the complete exclusion of the less mathematically inclined student, for the education of the technologist—that is to say, the man who will deal with to-morrow's problems and who can improve old processes and invent new ones. It is necessary for this man to have a sound grounding in the field of fundamental sciences, to be a considerable mathematician, and to have undergone the discipline of dealing with particular problems in detail. However, he must know when his passion for exact results is to be curbed in the interests of practicability.

It is encouraging to see an increase in research undertaken by university engineering departments, though some of it is of too academic a nature more fitted to pure science departments; and to note the attention being paid to methods of laboratory tuition. A change in the use of the laboratory from confirming lectures to developing an understanding of the methods of study involved in observation and inductive reasoning is taking place. This will mean demands for more laboratory time, probably at the expense of the drawing-office, since some of the courses given there could be postponed to run concurrently with the industrial apprenticeship.

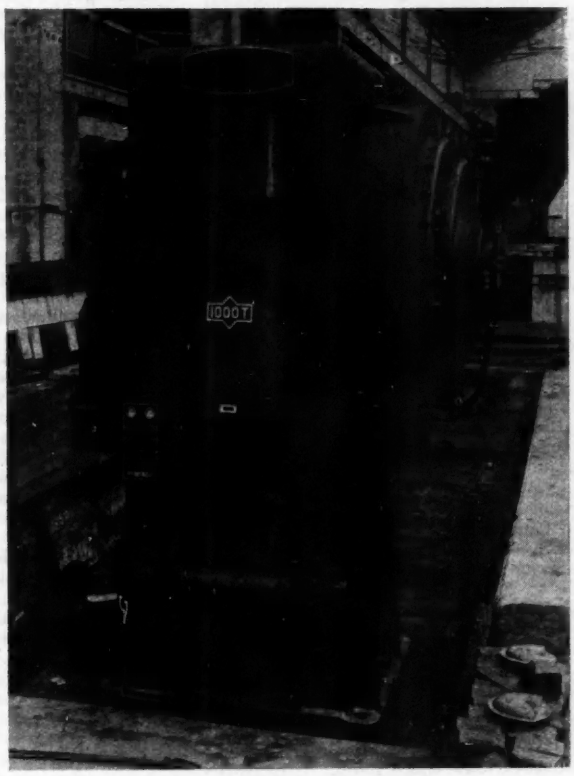
(To be continued)

Euston Resignalling.—The contract for the resignalling of Euston Station, London Midland Region, has been awarded to Westinghouse Brake and Signal Company, Ltd., which will be responsible for the supply and installation, with certain exceptions, of the whole of the apparatus. The installation will include 100 sets of electro-pneumatic facing point lay-outs involving the installation of approximately 2½ miles of air main and branch piping; more than one hundred a.c. condenser fed track circuits, covering a total of approximately 7 miles of track; thirty-one field locations using forty-four apparatus cases; one thousand a.c. relays, excluding the track relays, for various control functions; compressor plant, including two electrically driven compressors and one diesel-driven compressor, with automatic starting and control gear, switchboards, steel relay racks, fuse racks and disconnection racks. The 227-lever all-electric Westinghouse power frame to be installed was built some years ago, and held by the railway company as war emergency stock. This will be the first electro-pneumatic point operation installation at a main line terminus in London.

Mechanical Forging Presses

A NEW range of mechanical forging presses has been developed by B. and S. Massey, Ltd., of Openshaw, Manchester, for certain classes of die forging and extrusion work where the high production speeds of these machines can be used to full advantage.

Most forgings, particularly those of flat shape, require to be formed at a high speed to keep the dwell period of the dies and, therefore, the chilling effect on the forging, to a minimum. In the case of forgings which are produced by methods involving extrusion, if the speed of operation is too high, the rapid flow of the material results in short die life owing to the abrasive action on the die surfaces. In order to provide for these conditions two kinds of forging presses are being made by the firm—a high-speed machine, type "H," and a low-speed machine, type "L." The high-speed presses are made in sizes ranging from 250 tons to 3000 tons, and the low-speed presses in sizes from 250 tons to 1000 tons. These high-speed presses, up to and including the 1000-ton size, are not geared, the flywheel being mounted on roller bearings directly on the eccentric shaft, the speed of which is so high that ample energy can be stored in the flywheel. All other presses made in the range are geared. Should it be required, the high-speed press can be converted to the low-speed type and *vice versa*, as all the machines have a bored backshaft housing and provision is made for changing the position of the motor.



1000-TON FORGING PRESS

The press frame consists of a single steel casting of strong and rigid design, to ensure the maximum resistance to distortion, and to enable accurate forgings to be produced within small tolerance limits.

The sides of the frame are extended at the rear to give extra resistance to distortion, and these box-section extensions are fitted with covers to form chambers used as air receivers. This construction provides an effective means of clutch and brake air pipe mounting which reduces air losses to a minimum. All bearing surfaces in the frame are machined and, whether supporting static or moving loads, are fitted with replaceable bushes or liners.

In order to resist the pressures developed when producing off-centre work and to ensure accurate guiding, the ram, which is a heavily ribbed, stress-relieved, steel casting, has large guiding surfaces. It also has a very strong arm extending forward and upward, guided by additional slides in the crown of the frame. The slides, of phosphor-bronze, extend the full length of the "travel" of the ram and can be easily adjusted or replaced when worn. The ram is counterbalanced by a pneumatic cylinder at the rear of the frame and it can be arranged for water cooling, if desired.

The steel pitman has the outer surface of its lower end bedded accurately into the seating in the ram, which is fitted with a phosphor-bronze lining. The large diameter gudgeon pin runs in phosphor-bronze bearings, and the big-end is provided with a phosphor-bronze bearing made in halves and fitted with a long steel key to prevent rotation.

The load is well distributed over the large area of bearing surface through which the thrust is transmitted from the pitman to the ram, and wear is reduced to a minimum. Phosphor-bronze liners are also fitted on each side of the lower end to ensure free movement between the pitman and ram at these bearing surfaces.

The forged alloy steel eccentric shaft has large journals which are fully supported by the main bearings right up to the eccentric on both sides.

These main bearings of phosphor-bronze are made in two halves, the upper half, which is under pressure during forging, being fitted directly into the bore of the frame, from which it derives maximum support. The lower half is fitted into a steel housing, firmly locked in position by a substantial steel wedge.

All movement of the press ram necessary for production, die setting and maintenance, is controlled from a panel and a conveniently placed foot-operated switch.

Two air pressure gauges on the control panel indicate the regulator controlled pressure in the air receivers in the press, and the pressure in the supply line.

A rotary control knob on the panel enables the operator to correct for under or overrun of the eccentric at top dead centre. Two indicator lights are fitted, one for showing that current is available at the automatic rotor starter, and the other for indicating that the motor has reached operating speed.

A selector switch on the panel acts as an isolator and provides three alternative methods of control, "continuous" and "single stroke," which are obtained by use of the pedal, and "inching," which is controlled by special "forward" and "reverse" inching buttons. In the "continuous" position the press runs automatically as long as the foot switch is depressed, and the ram comes to rest finally at the top of the stroke. A further control may be provided, if required, which will enable a predetermined number of continuous strokes to be obtained for each operation of the pedal. This control is of special advantage in the production of forgings which require preforming or rolling. When operating in the "single-stroke" position a separate movement of the foot switch is needed for each stroke. Other buttons are for motor starting and stopping and flywheel brake application.

A multi-plate friction clutch is mounted on the eccentric shaft of all types and sizes of the presses, and is air operated and air cooled. In this clutch, shown in one of the accompanying illustrations, the parts to be set in motion and stopped at each stroke are of low inertia and comprise only the driven (inner) plates and splined hub. These parts are keyed directly to the eccentric shaft and their arrangement gives economy in power consumption, the minimum heating of the clutch and brake, and minimum shock to the frame in the event of a jam.

On the geared machines, the heavy tooth loads are shared by all the gear wheel teeth and not repeatedly borne by those of a small section of the circumference of the wheel, as is the case when the clutch is mounted on the backshaft. The heavier clutch parts, comprising the air cylinder, piston, splined housing and outer plates, rotate with the flywheel or gear ring and assist in storing energy. All the clutch plates are of manganese steel and the driving plates are faced with high-grade friction material.

MULTI-PLATE FRICTION CLUTCH OF 1000-TON PRESS

Clamping pressure by air is applied directly to the clutch friction plates through the piston, acting against powerful springs. When the air is exhausted from the clutch cylinder these springs return both the piston and end plate and also the outer clutch plates, and hold them securely on the coned seatings on the inner face of the housing. This arrangement has been adopted to eliminate cyclic hammering effect which would be detrimental to the long life of the splines of continuously rotating clutch parts. The plungers of the clutch return springs are flush with the ends of the spring covers when the clutch is initially engaged, and the amount of wear of the friction surfaces can be gauged at any time by admitting air to the stationary clutch and measuring the projection of the plungers beyond the covers.

Constant torque capacity of the clutch, and a reliable overload protection of the press, is obtained by controlling the air by means of a regulating valve at a constant pressure of approximately 70 lb per square inch. A special diaphragm seal is fitted in the clutch to ensure freedom from piston leakage, and allow air

line lubrication without the danger of oil reaching the friction facings.

The clutch is provided with internal fins and passages so arranged that whilst it is rotating a large volume of cooling air is drawn through the unit. Cooling air is admitted through a central annulus in the cowling at the unobstructed end of the clutch and exhausted at the periphery.

By this arrangement adequate provision is made for cooling the sealing diaphragm and all the friction surfaces, including the central plates.

The clutch friction plates and piston are assembled with the minimum end clearance, which, together with the efficient seal, short piping, built-in air receivers and special control valves, ensures low air consumption.

The main band brake is engaged by a powerful spring and released by compressed air. In order to provide maximum clearance between the top and bottom dies, this brake is arranged to arrest the ram in the top dead centre position,

RAM OF PRESS

and it may be adjusted easily and quickly to compensate for over or under-running of top position merely by turning a rotary knob on the control panel. A special time lag device ensures that the clutch is released before the brake is engaged. The brake drum is keyed and bolted on the end of the eccentric shaft and has a large number of radiating fins to provide a flow of cooling air.

To stop the flywheel "coasting" after power is shut off, a push-button controlled auxiliary brake, is provided. This brake is operated by an air cylinder unit, which presses a shoe on the rim of the flywheel. An interlock is provided with the motor stop button so that the starter is tripped when the brake is applied.

A heavy steel wedge with a large surface area supports the bolster and provides not only ready means of die adjustment, but also a means of release in the event of a jam. A micrometer index is provided to enable easy and accurate adjustments to be made to the die space.

Top and bottom mechanical ejectors fitted on the machine are so arranged that ejection occurs at the earliest possible moment. Provision can be made for the addition of an air ejector mechanism in cases where delayed or long-stroke ejection is required.

The machine is lubricated by an independent, motor-driven, multi-feed oil pump, and points requiring infrequent lubrication are fitted with grease gun nipples. Through electrical interlocks the lubrication system is set in motion before the press can be started, and the press is stopped in the event of failure of the lubricator motor. In addition to the separate adjustable sight feeds provided in the main lubricating unit, sight feeds for the three main bearings are also mounted on the control panel in a position where they can readily be checked by the operator, and as a further precaution the oil feed to these points is duplicated.

The press is arranged for vee-rope drive from a slip-ring motor mounted at the rear of the frame. The motor, with external slip resistance, is specially arranged to give exceptionally high slip, and the starter is of the automatic stator and rotor type.

A stroke counter is fitted to give a ready means of checking for production and maintenance purposes, and an electrically operated remote counter can be supplied.

Railway Economics in Canada*

By W. A. NEWMAN, C.B.E.†

In Canada, general inflation, a 40 per cent increase in population in twenty years, greatly increased industrialisation and growing competition from other forms of transport are jointly having a profound effect upon Canadian railway operations and standards of equipment.

Before dealing with my subject specifically, let me focus your attention on background conditions. Here in the British Isles, railways were introduced into a settled country, with centres of population and some volume of established traffic; distances being relatively small, the standard of railway construction was more or less determined by established needs. In America, railways were the instruments by which a vast continent was opened to settlement; distances were great and the railway future entirely dependent upon the extent and rapidity of immigration, so that railway construction standards were naturally determined by these uncertain conditions.

The Canadian Pacific Railway is an excellent example of this, as its charter states that the railway was for the purpose of joining the Pacific to the Atlantic seaboard and for the development of the North-West territories.

It was imperative that construction costs be kept to a minimum, owing to the large amounts of capital required for the great distances to be covered and the prospects of comparatively thin density traffic for an indefinite period in the future. Consequently, generally in America and particularly in Canada, the railways were single track. They skirted hills, lakes and other obstacles, and gradients were set so that construction costs were a minimum.

Although great improvements have been made by better ballasting, laying of heavier rail, straightening line and reducing grades in a few places and by double-tracking some sections of main line, Canadian railways are still basically single track and, except where the country is naturally flat, are characterised by frequent grades and curves. Main line grades are up to 2·2 per cent in mountain territory.

Economic conditions have never been static in any land. However, economic developments in Canada, since 1940, have profoundly affected the railways. Prior to 1940 Canada was over-supplied with railway mileage. Natural growth and changing economic conditions were readily met by improvements in weight and standards of track structure, increased capacity of freight-carrying rolling stock and by the increasing size and capacity of steam locomotives. However, following the depression of the 'thirties and the war and post-war period from 1940 to 1950, Canadian railways were suddenly faced with entirely new transport problems. The first basic reason was an increase in population of 40 per cent between 1930 and 1950. This meant that normal growth in volume of traffic commenced to tax the capacity of many portions of single-track main lines.

Of even greater effect were the increasing industrialisation and change in character of the goods carried, the very marked effect of other forms of competitive transport and, last but certainly not least, the general effect of inflation and the resulting cost of operation.

From the railways' point of view, inflation has had the following effect upon basic costs:—

The average cost for mechanical department labour has increased 114 per cent from 1939 to 1951; and the average cost of materials has increased by about 140 per cent in the same period.

More specifically, the average cost of railway coal has increased from a system average of 4·12 dollars per short ton to 8·12 dollars, an increase of 97 per cent. The average cost of freight cars has gone up from 3750 dollars per unit in 1939 to 8800 dollars in 1951, or 135 per cent. It is difficult to give an exact comparison for steam locomotives, but it is judged that the increase in cost would be approximately the same.

These are the background conditions now prevailing and naturally they have increased our operating costs. Freight rates have not, in general, been advanced sufficiently to compensate for the present difficult economic conditions. The effect upon the railway user, however, may be judged from the fact that our average revenue per ton-mile in 1885 was 1·20 cents. For sixty years this average revenue declined and was generally considerably under 1 cent per ton-mile, standing, as late as the year 1947, at 0·95 cent per ton-mile. Following the war and post-war inflation, Canadian railways were not permitted a general increase in freight rates until April, 1948. This, together with subsequent increases yielding 30·4 per cent over 1938 rates, brought the average revenue for 1950 up to 1·33 cents per ton-mile. In terms of 1939 dollars this average revenue for 1950 is about three-quarters of a cent per ton-mile.

Our present problem is: "How to produce better transportation at lower costs." The problem involves both standards of transport and the equipment or tools that produce such transport. We will first refer to railway operation. This, in turn, may be divided into two parts: the movement of traffic on the line and the handling of traffic through terminals.

Railway Operation

Changed conditions have produced two results in single-track main line. They have either increased density to the point where traffic flow has become inadequate or they have created bottlenecks in sections where operating conditions are difficult. High-density traffic can be accommodated only by increased railway capacity, which means faster train operation, heavier trains and greater frequency. So far, on account of the great mileages involved and high capital costs, double-tracking is not being considered and will not be, until we have fully exhausted all other means of increasing railway line capacity.

Generally speaking, our track standards are good as regards weight of rail and bridges or other structures. Train operations between terminals have been constantly improved by the progressive installation of automatic block signals and all main lines will be so equipped in a few years. Longer passing tracks of adequate capacity to take increased size of trains, are increasingly necessary and are being systematically provided. Studies made indicate that centralised traffic control will give single-track capacity almost approaching that of double-track line.

These are the basic line conditions necessary to allow the operation of heavier trains with faster average speeds and greater frequency. Given these conditions, there still remains the problem of actually operating such trains. The answer, the result of intensive studies and experience, lies in the use of diesel-electric or equivalent types of locomotive.

Existing steam locomotives in America are built right up to the limit of permissible track and bridge loads. The basic diesel-electric unit, generally limited to 62,000 lb per axle and of 1500 h.p., will, with four units, give

* Abstract. Address, "The Effect of Changing Economic Conditions in Canada on Railway Operations and Equipment," Institution of Locomotive Engineers, May 22, 1951.

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a locomotive up to 6000 h.p. or even more. Such a locomotive, with no dynamic augment, comes well within track and bridge load limitations, so that line capacity, as regards weight of trains, is practically limited only by the permissible maximum length of trains or any particular operating restrictions that may exist in a specific area.

A good example of diesel operation is the Schreiber Division of the Canadian Pacific Railway, lying along the north shore of Lake Superior. Curves are very numerous, which generally means a limiting maximum speed for freight trains of approximately 45 m.p.h. Grades are quite frequent and in any one subdivision tonnages are limited by one or more ruling grades. With two-unit 3000 h.p. diesel-electric locomotives, whose maximum horsepower is practically equal to the steam locomotives which they displaced, the tonnage rating has been increased from 1660 tons to 3150 tons, an increase of about 90 per cent. This means about half the number of trains will be operated for a given volume of tonnage, or conversely, the desired result of nearly doubling the line capacity with the same number of trains. If necessary, the line capacity can be increased an additional 50 per cent by the use of three-unit, 4500 h.p. locomotives.

As far as purely operating conditions are concerned, the changes now in progress are: better signals, improved means of controlling the movement of traffic and increase in the weight and speed of trains.

At present in Canada freight equipment spends 50 per cent of the calendar time in terminals. With the growing cost of equipment and the necessity of providing better service, it is essential that time spent in terminals be reduced and various developments and improvements are being introduced to secure that objective.

Railway Terminals

In Canada terminals have become hemmed in by the expansion of cities and towns and track lay-outs and facilities in many cases are not adequate to handle present or future requirements.

In Montreal the Canadian Pacific Railway has constructed a new freight terminal at Cote St.-Luc, at a cost of over twelve million dollars. The traffic flow in this yard is unidirectional, as incoming trains from all directions converge on a receiving yard and are passed over a distributing hump, with all-electric car retarders controlling speeds to all classification tracks. This terminal has completely new facilities for all purposes and every aid is provided to secure the highest efficiency with the highest capacity. Yards similar to this will have to be constructed in other principal cities in Canada, where existing terminal facilities are now overloaded.

Freight terminals were originally located approximately 125 miles apart, more or less to conform with the early requirements of changing locomotives and crews after about 125 miles of operation. Now that locomotives can be operated almost indefinite distances, the trend is towards the marshalling of cars in trains and the inspection of trains and equipment at terminals where schedules or conditions require stops of some duration, so as to permit operation with very much reduced detention at other intermediate terminals. The diesel-electric switching locomotive of 660–800 h.p. and 1000 h.p. has been adopted as standard for all terminals of any size.

Adequate communications are indispensable to the most efficient operation of large yards. The introduction of radio telephones on diesel locomotives, controlled from the yardmaster's office, has resulted in considerably greater flexibility and efficiency in handling of car shifting and switching operations. Recently car checkers, who collect essential data on cars in yards by visual inspection, have been equipped with walkie-talkie radio sets, enabling them to transmit their information instantly to the yard office or other control point.

One of the greatest difficulties in yard operation has been the securing of train consist information sufficiently in advance of arrival of the train. Prevailing methods were to telephone or wire wheel reports or train consists from terminal to terminal, which was time-consuming and required extensive clerical staff. It also imposed a major burden upon communication systems.

This is now being overcome by a system introduced on the Canadian Pacific Railway during the past few years, and which is being extended. It consists of individual car records at receiving points being in the form of cards punched by International business machines to record car identification, contents, routing, destination and any other pertinent information required. When a train is assembled cards representing individual cars are assembled in the order in which the cars are marshalled in the train. These cards are then put through an International business machine that produces a tape on which is transcribed by symbols all the information relative to the train consist. This tape is then put through a teletype transmitter, which reproduces, typed, at every terminal concerned, all the information relative to the train and this is available before or immediately after the train leaves the originating terminal. Such data are of particular value in modern terminals, so that plans can be made in advance for the disposition of all cars on incoming trains, including the classification of cars for distribution as they go over the hump.

Ice and snow interfere seriously with yard operations. In important yards the use of propane gas heaters under switch points is being introduced to prevent the formation of ice and give free movement of switches under all conditions.

Snow melters have been introduced over the past few years. With these, snow is gathered, fed to a conveyor belt and then fed into a 15,000 gallon tank and melted by means of steam and hot water, the steam supply being drawn from the steam locomotive which pushes the snow melter.

During the past winter the Canadian Pacific Railway has introduced a new type of snow melter, which has vertical and horizontal gathering vanes with a cross-shaft on which are mounted rotating blades, which break down the snow and throw it back into high-capacity blowers. A blower outlet can throw the snow to either side of the track or back into a snow melter. The side deliveries can be used for loading snow directly into trucks or cars on parallel track.

All the above, including new types of yards, diesel locomotives, improvements in communication and new methods for yard clearing and operation, are all intended to improve efficiency of train handling in terminals and to reduce detention time, resulting in better car utilisation with better service to shippers.

The movement of passengers is not profitable on Canadian railways. On the main lines and on certain other lines there is sufficient volume to provide for the payment of costs, but this is more than offset by the extensive passenger mileage on branch lines, where the density of traffic is low. There is no place in Canada where it is considered that the cost of highly specialised streamlined trains could be justified. Canadian Pacific policy for movement of passengers is to provide comfortable, safe and reliable transport. A good deal of new equipment is being introduced currently, but our ability in this connection is restricted by the extremely high cost for modern passenger cars. The steady increase in cost is accentuated because of the demand for complicated, expensive air-conditioning, heating and electrical systems, general furnishings and other modern requirements.

The movement of freight, particularly in carload lots over long distances, is the primary business of Canadian railways. Most freight is transported in what we term universally used types of freight equipment. These are essentially box cars, flat cars and open-top gondola cars. Gradually, however, specialised cars have also become more or less standard, such as stock cars, hopper coal cars, drop-bottom gondola cars, automobile cars and refrigerator cars.

At the present time on the Canadian Pacific Railway a complete survey is under way into all methods and facilities for inspection and maintenance of freight equipment, in order to make sure, first, that cars do not travel more than the absolute minimum distance before being given the necessary attention and, second, that they are held out of service for attention the least possible time. An additional purpose of the survey is to provide a system of inspection and preventive maintenance for freight cars, so that they can be operated over several subdivisions without any detention at intermediate terminal points for inspection or repairs.

The average cost of equipment to a Canadian railroad is about 35 per cent more than to a United States road. At to-day's prices the investment required for the Canadian Pacific Railway's freight car inventory would be 175,000,000 dollars greater than what it would be for a comparable United States railroad.

Locomotives

The proportions of Canadian Pacific steam locomotives are very carefully determined, so as to give good average efficiency over widely varying conditions of operation and climate. These distinctions in the design of steam locomotives have meant that for individual railroads locomotive builders simply produced locomotives to their customers' designs, specifications and requirements.

Up to 1940 it was difficult to justify economically the diesel-electric locomotive which was available at that time. The introduction of diesel-electric locomotives in switching service and for the movement of freight trains opened up an entirely new phase in the utilisation of this new form of power. Once the use of diesel-electric locomotives grew to the point where mass-production was possible and, concurrently, steam locomotive costs rose the economics of the two classes of power were on a different footing. At the present time the cost of diesel-electric locomotives is relatively little in excess of the cost in 1939 and 1940. In other words, mass production with standard designs only, so that the same basic locomotive is used on all railroads, has kept the cost more or less stable in spite of the changed economic conditions in the past ten to twelve years.

The effect of the diesel-electric locomotive on operations in removing the limitations now existing for steam locomotives and in profoundly affecting operating costs, has resulted in decisions, gradually reached, that no new steam locomotives will be acquired. This applies in Canada as well as the United States and locomotive builders in both countries have converted their domestic operations to the production of diesel-electric locomotives only.

This should not be interpreted as meaning that the steam locomotive will disappear in Canada. Diesel-electrics can be used only where utilisation is sufficient to produce savings.

On the Canadian Pacific we have determined that, depending upon the relative prices of fuel, diesel-electrics cannot be expected to produce advantages and economies unless we can operate them a minimum of approximately 2000 miles a month. However, we have many areas where we provide transport services with very thin traffic and the existing small and medium-sized steam locomotives, which we now have in our inventory and which were acquired at relatively low cost, will probably prove the most economical form of power for many years to come.

By our policy of introducing diesel locomotives in areas where they provide the greatest gain in transport capacity or in efficiency and economy many steam locomotives are displaced, so that gradually the best and most suitable of our steam locomotives will be redistributed and sufficient retained to provide for operations where they will continue to be the most suitable.

With locomotives in Canada required for more or less general use, we have standardised on a general purpose diesel locomotive, which can be operated on either freight or passenger service and in all areas, such as mountain territory or, conversely, prairie territory, where maximum and average speeds are considerably greater. All that is necessary to

vary the maximum permissible speeds is to change the gear ratio between the traction motors and the axles.

So far in Canada we have avoided the use of diesel-electric locomotives in passenger service for the reason that automatic steam generators, so far provided for train-heating, have been complicated and not sufficiently reliable for the very severe Canadian winters. Within a period of one to two years it is considered that sufficient reliability will have been secured to permit the use of such locomotives in passenger service, particularly as in main line use two-unit locomotives with two boilers will be used.

The maintenance of diesel-electric locomotives has a very distinct bearing upon the service that can be obtained. On the Canadian Pacific Railway our maintenance is based upon aviation methods; that is, preventive maintenance in which, by inspection, checks and tests, every component and functioning part of the diesel-electric locomotive is determined to be in proper operating condition to ensure its use over the desired mileage. If any parts or components are not functioning properly, they are removed and replaced with ones in proper condition.

Our maintenance planning provides for three principal running maintenance points serving the entire 3500 miles of main line on the Canadian Pacific, on which diesel-electrics may eventually be used. This is based on the cycling of locomotives in such a way that they will return to maintenance points at sufficient intervals for their periodic checking.

While our experience in the use of diesel-electric locomotives does not exceed ten years, we do not expect that the overall cost of maintenance per 1000 gross ton-miles will be greater than that of steam locomotives.

There is no question that the diesel-electric locomotive will be developed considerably beyond its present performance and overall efficiency.

This address has been confined to a broad coverage of rail transport conditions in Canada, the difficulties imposed upon us by the very major changes in economic conditions and what is being done to overcome the handicaps under which we have to operate. It is to be noted that Canada presents a unique condition in railway operation. On the one hand we have the government-owned Canadian National Railways, formed in the mid-'twenties from a group of bankrupt railways resulting from the construction of railways at a faster rate than Canada was developing. This system has now been developed into a well-integrated and well-run railway, supplying Canada with excellent transport at relatively low costs. On the other hand, we have the Canadian Pacific Railway, which is perhaps the last large, private-enterprise railway system in the Commonwealth.

The principal function of the Government system is to provide good transport at as low cost as possible. Possibly it is not so restricted in its development as the private railway and certainly by comparison we in the Canadian Pacific feel we have had to learn to do much more with much less, as far as transport facilities and equipment are concerned. On the other hand, the private railway, with its careful correlation of operating expense to revenue and investment, has been able to control operating costs to a considerable degree in spite of prevailing adverse conditions.

Improvement of Home Service Coverage

THE B.B.C. believes that its Home Service is at present satisfactorily received by about 92 per cent of the population of the United Kingdom, though in some areas reception is subject to interference from foreign broadcasting stations, especially during the evenings in winter. It is not possible to make any widespread improvement in coverage because of the shortage of wavelengths available for use by the B.B.C. These wavelengths, it will be recalled, were allocated by agreement between the governments of countries in the European Zone at a conference held in Copenhagen, and the resulting Wavelength Plan was put into effect in March, 1950.

B.B.C. engineers have made a detailed study of reception conditions since the Copenhagen Plan came into force and have worked out a scheme for making local improvements in reception of the Home Service in certain parts of the country. This plan, which has now received the approval of the Postmaster General, provides for twelve low-power transmitters to be brought into service in areas where they are most needed and will benefit the greatest number of people.

In finding wavelengths for these new stations, either wavelengths must be shared with existing B.B.C. transmitters or use must be made of the International Common Wavelength which most countries have the right to use. There are objections to both these courses. When two transmitters share a wavelength an "interference area" is created in which reception is poor and may be intolerable. Stations which share a wavelength must therefore be chosen very carefully or the loss of population coverage may be greater than the gain. Of the two International Common Wavelengths, 188m is off the tuning scale of most receivers at present in the hands of the public and will therefore not be used in this scheme. The other, 202m, is of limited value because the power is restricted to 2kW by the Copenhagen Plan and the range is further limited by interference from the many continental stations also using it. The present scheme for additional Home Service transmitters is tabulated below. It will be seen that in some areas it is not practicable for the transmitter to radiate the Home Service of its own Region for the reason already explained. It is expected that at least some of the transmitters will be in operation before the winter of 1951–52:

Additional Transmitters and Areas Served

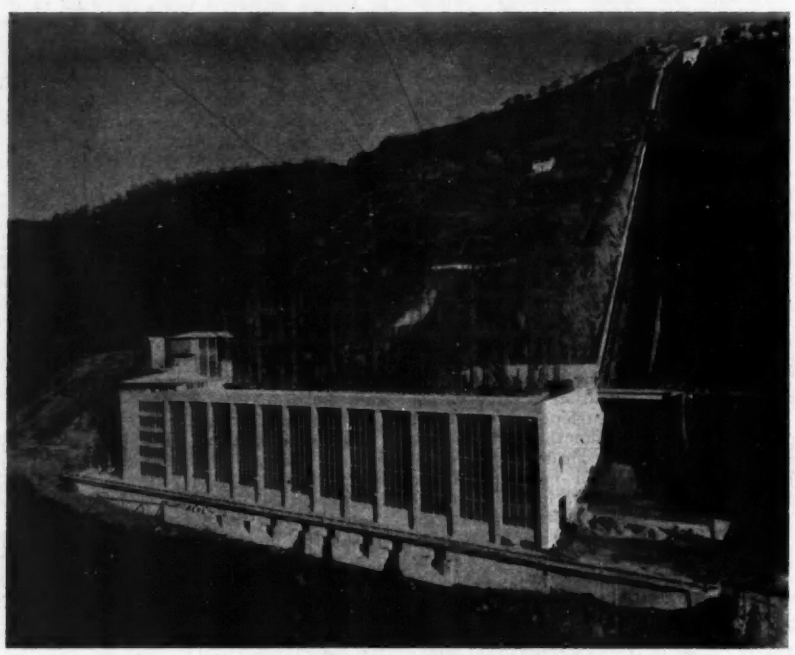
Location	Wavelength, m	Frequency kc/s	Programme radiated
Barnstaple ...	285	1052	West of England
Scarborough ...	261	1151	Northern Ireland
Bexhill	206	1457	West of England
Folkestone ...	206	1457	West of England
Brighton... ...	206	1457	West of England
Whitehaven ...	434	692	North of England
Barrow	202	1484	North of England
Ramsgate ...	202	1484	London
Pwllheli	341	881	Welsh
Cromer	330	908	London
Montrose... ...	202	1484	Scottish
Dumfries... ...	371	809	Scottish

Unfortunately, reception conditions in Europe on the medium wave band are likely to get worse as the number of broadcasting stations and their power increases. The B.B.C. therefore stresses the importance of keeping receivers in good working order, because the slow deterioration in performance that inevitably occurs in the course of time leads to weak reception, fading and interference from other stations. For the same reasons it is emphasised that a good outdoor aerial should always be used whenever circumstances permit.

The Vila Nova Power Station, Portugal

AN important stage in the development of hydro-electric power in Portugal was reached on Saturday, June 9, 1951, when the first of three generating sets was put into commission in the power station at Vila Nova, about 60 miles north-east of Oporto. Vila Nova is situated on the banks of the Cavado River near the confluence with its tributary, the River Rabagao, and the scheme for the development of the Cavado-Rabagao basin has been entrusted to the Hidro Electrica do Cavado, a company formed for that purpose. The station is being equipped, in the first instance, with three 39,000 h.p. turbines, each consisting of horizontal shaft double-runner Pelton machines coupled to a 32MW generator running at 428 r.p.m. There are also three 30MVA, 11/165kV three-phase banks of single-phase transformers and 165kV and 30kV switchgear, including air blast circuit breakers. The hydraulic and electrical equipment installed has been supplied by the English Electric Export and Trading Company and Metropolitan-Vickers Electrical Export Company, who have become known in Portugal as the British Group. Room has been left in the power station for a fourth set to be installed at a later date, when the demand for electrical power in Portugal has been sufficiently developed. As may be seen from the accompanying illustration, the power station has been built on a somewhat restricted site, the switchgear substation being built on the roof.

The water for the power station at Vila Nova is derived from the River Rabagao, which flows at this point some 2 miles to the south-east at an altitude approximately 1500ft higher. A dam about 300ft high (the Venda Nova dam) has been built across the River Rabagao, the reservoir which it forms being connected to the power station through a tunnel driven through the mountain for a distance of about 1½ miles

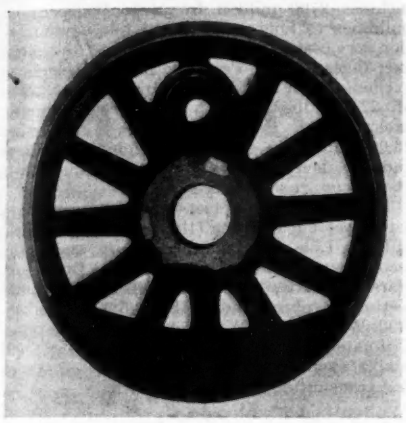


VILA NOVA POWER STATION, PORTUGAL

to a valve house situated at the top of a steep declivity which runs down to the Cavado River, on the banks of which the power station has been built. At the valve house the water enters a steel pipe-line and is led into the power station from which, after passing through the turbines, it finds its way into the Cavado River. The steel pipe-line is 8ft in diameter and about 950ft long and was supplied and erected by the South Durham Steel and Iron Company, acting as sub-contractors to the British Group.

Locomotive Wheel Centres

We have received from K. and L. Steelfounders and Engineers, Ltd., of Letchworth, Herts., some notes on the "SCOA-P" wheel centres for locomotives, which it is now manufacturing. The development of this cast steel locomotive wheel was instigated by one of the State Railways of Australia, some time ago, when it was faced with the problem of introducing on its heavier locomotives wheel centres of orthodox



"SCOA-P" Locomotive Wheel

design but without any increase in weight. The railway in question failed to find any satisfactory solution to its problem in any of the existing designs of spoked or disc wheels and approached the Steel Company of Australia, Pty., Ltd. After investigating the problem that company evolved the new design of wheel and called it the "SCOA-P," after its own initials, and the name of the designer, Mr. F. C. Paynter.

The new wheel, which is illustrated above, has spokes of U-shaped section cast integral with a rim of channel form in sections. It is claimed that with this design the accessibility offered by the spoked wheel is retained but the metal is disposed in such a way that a much stronger form of wheel is produced. The U-shaped spoke is appreciably stronger, both as a column and as a beam for resisting both vertical and lateral shocks, and the channel form rim is stated to provide a much better support for the tyre between the spokes than a conventional rim. In the manufacture of the new wheels the danger of undiscovered cavities between the spokes and the rim is eliminated by the way in which the U-spokes and channel rim are blended.

When the wheel was adopted by the Australian State Railway its possibilities were recognised by K. and L. Steelfounders and Engineers, Ltd., and the company acquired the manufacturing rights. The firm is associated with the Vulcan Foundry, Ltd., of Newton-le-Willows, which acts as designing engineers and consultants for all wheels of the kind fitted to locomotives built in territories outside Australia.

A Rolling Mill Drive

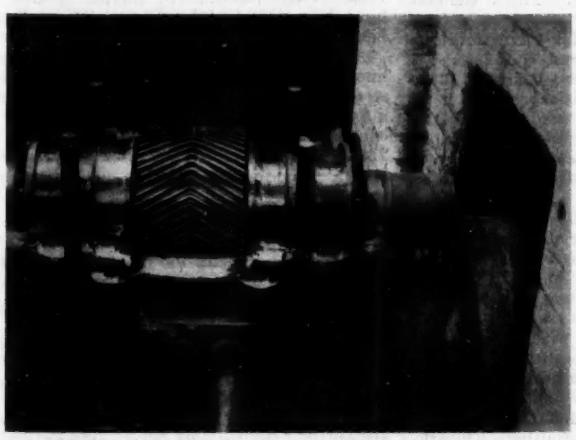
We have received from David Brown and Sons (Huddersfield), Ltd., an interesting note on a long-service performance by a rolling mill drive unit made by the company. The gear train unit in question has given thirty-three years' trouble-free service, driving two three-high wire and rod mills at the works of Andrews Toledo, Ltd., at Sheffield, and it is still working.

The 14in train was manufactured in 1918 and was installed with several other sets of various sizes made to the same order. It is normally required to transmit 300 h.p. at 260 r.p.m., although the gears have been subjected to the very considerable overloads associated with rolling mill drives.

Although precise records of tonnages rolled at these mills date back only to 1934, it is estimated by the firm concerned that these gears, which are of 4 D.P., with 10in face width and fifty-six teeth, have so far helped to produce approximately 320,000 tons of high-quality steel, mostly for colliery winding and haulage equipment, suspension bridges and similar applications. Other steels handled include needle wire, music wire, silver steels, and a wide range of alloy steels for special applications.

The performance is noteworthy in that, owing to the inaccessibility of the unit, in addition to the need for continuous operation, normal maintenance has not been possible.

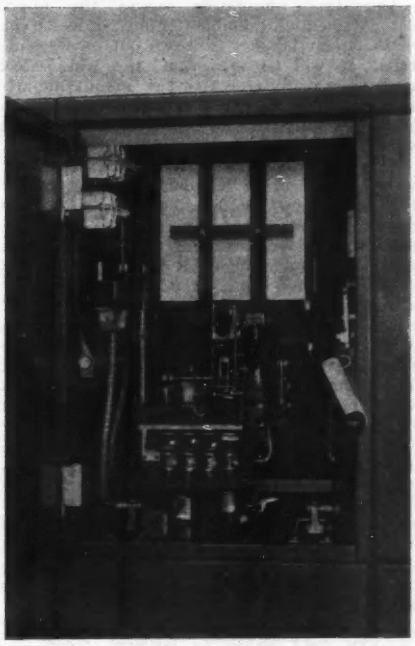
The accompanying photograph was taken recently when the gear-box was opened for inspection for the first time in ten years. As the illustration clearly shows, the pinion teeth were in excellent condition, and it is stated that the amount of wear apparent at the bearings was negligible. As all the other parts were also found to be in sound condition at the inspection, the unit was put back into service.



Gear Unit Open for Inspection

Medium Voltage Air-Break Switchgear

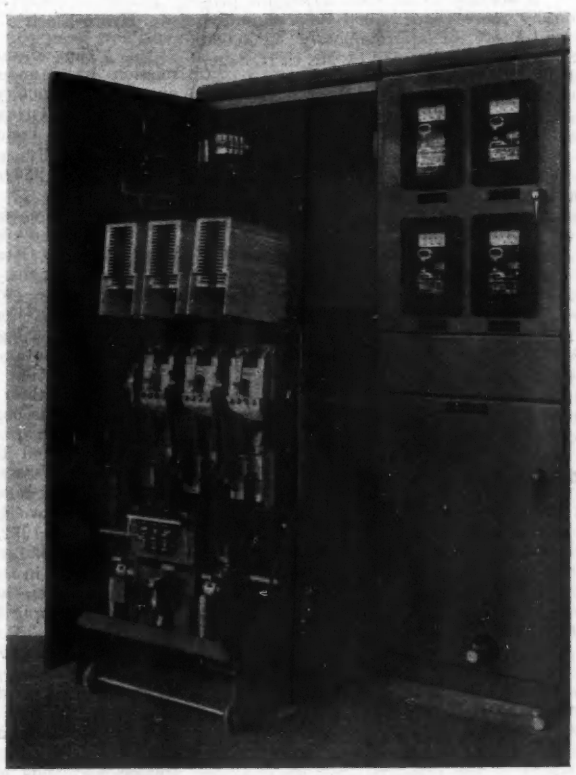
We have recently received particulars of a new range of medium voltage air-break switchgear manufactured by the General Electric Company, Ltd., for service in power



Double Tier Switchboard with 800A Circuit Breaker Isolated

stations and substations. The switchgear is suitable for operating voltages up to 600V a.c. and is available in single, double or four-tier arrangements as follows: single-tier for circuit breakers up to 3000A; double-tier for circuit breakers up to 800A, and for isolators of all ratings; and four-tier for fused switches up to 400A and for contactors.

The switchgear is housed in sheet steel



Single Tier Switchboard with Circuit Breaker Withdrawn

cubicles, which are of standard height and depth and can be assembled to form a complete switchboard to suit the particular requirements of any installation. A range of horizontal draw-out circuit breakers with rupturing capacities of 15MVA to 30MVA at 400V is available, the current rating of the three sizes being 800A, 2000A and 3000A.

Our first illustration shows the upper compartment of a double-tier unit, in which the 800A circuit breaker is drawn out on its slide rails. It will be seen that the wide steel doors give ready access to the main compartments. The other illustration shows a single-tier unit with its 2000A circuit breaker withdrawn on its wheel-mounted carriage.

The circuit breakers can be arranged for either electrical or manual operation, means for emergency handclosing being provided on all solenoid-operated units. The operating handle is a lever attached to a shaft, which projects through the door of the cubicle and which is fitted with a pointer to indicate whether the breaker is in the "on" or "off" position. This operating shaft also provides a clearly visible indication of whether the breaker is in the service or isolated position. The circuit breaker is isolated by means of a screw and nut racking mechanism operated by a loose handle—which moves the breaker forward in the cubicle, thus opening the isolating contacts. As the breaker moves forward, the operating shaft moves with it and projects further through the cubicle door until, eventually, when the breaker is fully withdrawn, a mark on the shaft is revealed, which shows that the breaker is isolated. With this arrangement it will be appreciated that total enclosure is preserved when breakers are isolated.

A sheet steel door at the back of the cubicle provides easy access to busbars, cable terminals and current transformers, which are housed in the rear section of the unit. All doors are provided with locks and the equipment is fully interlocked to guard against maloperation.

Canadian Engineering News

(By our own Correspondent)

Paper Mill Expansion

A scheme to increase newsprint production by more than 12,000 tons annually, with an outlay of approximately 5,000,000 dollars, has been announced by Mr. C. H. Sage, president of the Spruce Falls Power and Paper Company, Ltd., Northern Ontario. Work will begin immediately and it is expected the project will be completed before the end of 1952. The new programme is a major stage in a long-term expansion project, which was begun in 1947, but which has so far been confined to the rebuilding of one newsprint machine and to community expansion. With supporting pulp-making facilities correspondingly enlarged, the new Spruce Falls project involves the rebuilding of the three remaining paper machines and a programme of general mill and plant modernisation. Major components of the mill modernisation programme include a new upstream jackladder, a full-length belt conveyor for the wood-yard, and the installation of new multi-knife chippers in the rossing plant.

New Chemical Plant

Dow Chemical of Canada Ltd., will build a plant in Sarnia, Ontario, to produce anhydrous ammonia. The contract for the construction of the new plant has been awarded to the Austin Company, Ltd., and construction will start immediately. The plant will be generally similar to that now operated by the Dow Chemical Company at Midland, Michigan, and Freeport, Texas. The engineering work is being handled jointly by the Sarnia and Midland engineering departments. The total cost of the plant will be in the neighbourhood of 1,000,000 dollars. Hydrogen, which is the principal raw material to be used, is being produced in the Dow chlorine-caustic plant at Sarnia. The new plant will combine this hydrogen with nitrogen from the air, under high pressures, to produce ammonia. The designed capacity of the plant is 15 tons of ammonia per day and provision is being made to permit rapid expansion if it is found to be desirable.

"Orenda" Jet Engine

A 2,500,000 dollar capital assistance grant has been approved by the Federal Government to increase production of magnesium castings for North America's most powerful jet engine, the "Orenda." The expansion will take place at the Dominion Magnesium Company's plant at Haley station, sixty miles west of Ottawa. The money will be used to finance construction of additional plant floor space and installation of new production machinery. Under the new capital assistance plan the Government will have complete control over new equipment and floor space used by the company for increased output. Whenever this production comes to an end and no further castings are required, the company may purchase the extension from the Government or the Government may dispose of it in some other way.

Combination Steel Mill

The first combination steel mill to be put in operation in Canada is being installed at the plant of the Algoma Steel Corporation at Sault Ste. Marie, Ontario. The value of the mill is said to be in the neighbourhood of 10,000,000 dollars. It is being built by the Morgan Construction Company, of Worcester, Mass. Although several combination mills are in operation in the United States, the new mill will be the first of its kind in Canada. It is expected to be in production early in 1952. Mechanically, the mill will be capable of turning out both merchant and skelp narrow strip products. The merchant part can manufacture steel sections such as steel bars and concrete reinforcing rods, while the skelp section is used chiefly for developing the initial material later used in manufacturing welded pipe, tubing and other equipment. For some time skelp material has been imported into Canada and the Algoma Steel Corporation will enjoy an enviable position as a home supplier to Canadian industry.

Hydro-Electric Progress

The Ontario Hydro-Electric Commission has announced that it intends to extend the 55,000,000 dollar La Cave development on the Ottawa River five miles north of Mattawa to eight generator sets instead of six as originally scheduled. This will mean an output of 256,000 h.p. or an increase of 64,000 h.p.

At an estimated outlay of 160,775,000 dollars, the Commission is making good progress with the Ottawa River projects at Des Joachims, Chenaux and La Cave, which, when in full service, will provide 896,000 h.p., surpassed in the Commission's system only by plants in the Niagara area. The Joachims and Chenaux stations are now generating power, while construction at the La Cave development is more than 60 per cent complete. La Cave, which was begun in the autumn of 1948, is expected to provide initial service next November, when the first two of its eight generator sets are scheduled for operation. Four more will follow at one month intervals and the final two are scheduled for service in the autumn of 1952.

Completion of La Cave will mark a specially important step in the pooling of electric power, since this generating station is conveniently situated to supply both the Southern Ontario system and the Northern Ontario properties. Power from La Cave will be transmitted over a 115kV circuit connecting with a line from Crystal Falls generating station to the Sudbury frequency-changer and transformer station, while a 230kV transmission line will connect La Cave with the Des Joachims generating station and thus with the Southern Ontario system.

French Engineering News

(From our French Correspondent)

A new rolling mill has just been installed at the Homécourt factory of the Union Sidérurgique Lorraine (SIDELOR). The rolling mill comprises a continuous, seven-roller rough-rolling mill; a four-roll staggered train and three finishing rolls. Total power of the driving motors is 3500 h.p. Billets 9m 50 long by 50mm and 70mm, will be fed to the mill from an automatic oven with a capacity of 45 tons an hour, and with a mechanical loading grate. The rolled iron will emerge either on 70m long oblique cooling rollers or to the winding machines.

The plant covers 17,400 square metres, and will shortly be completed by the addition of a 5000 square metre warehouse. Its production programme is varied, but will consist mainly of the rolling of bar iron for bolts and the delivery of bar iron with rims up to 23mm in diameter. The mill will produce 180,000 tons annually and will shortly come into service.

* * *

The French Post Office programme for 1951 includes 2700 million francs to be spent on buildings to house postal and telecommunication services, and the construction of telephone exchanges. The Paris automatic telephone exchanges will be developed by the installation of 22,000 lines and a 5000-line automatic exchange at Enghien-les-Bains. A further 23,000 lines for new or extended exchanges and the development of provincial automatic exchanges are also envisaged.

The television equipment programme involves a first section of eight (1kW to 5kW) stations in Paris, Lille, Lyon and Strasbourg, and in the second part of this section stations at Bordeaux, Marseilles, Nice and Toulouse. The second section involves about thirty-five secondary (300kW to 500kW) transmitting stations. Ultimately a Paris–Lille Hertzian relay will enable exchanges to be made between direct and transmitted programme stations.

* * *

Parliament has authorised the expenditure of 112½ milliard francs by Electricité de France for new works in 1951. Since 1947 over 3 milliard kWh of hydraulic power has been added annually to the country's production. During 1950 the hydro-electric works which were completed will give an increased output of almost 1100 million kWh, and the works now in progress will give an estimated power increase of 5·7 milliard kWh, of which schemes corresponding to almost 1·8 milliard kWh will be ready by the end of this year, 2 milliard kWh in 1952, and about 1·9 milliard kWh in 1953, when it is expected that the entire programme will be completed. It is likely that preparatory work on a new programme of works will begin this year, to be put into operation when the present one is completed.

From 1947 to the end of 1950, the installed capacity of thermal power stations increased by 490MW, of which 240MW was in 1950. Work now in hand will give an increase of 634MW—374MW in 1951, and 260MW in 1952. Over 1400MW of thermal power will have been installed by Electricité de France between 1947–1953.

At the end of 1950, about 4700km of overhead line and underground cable had been constructed, which, together with transformers installed was equivalent to an increase in capacity of 2050MVA. Extensive work on 220kV and 150kV networks is at present in hand, including 1000MVA of transformer capacity.

* * *

Damage caused by storms in the Upper Alps has made it necessary for Electricité de France to blow up the main flood gates of the Prelles barrage, constructed on the Durance, 5km from Briançon. Trees which had fallen in the storm had been carried by the water against the sluice, making normal spilling impossible. The level reached 80cm above the normal maximum, and it was therefore decided to blow up the flood gates to avoid any damage to the substructure of the barrage or to ancillary installations.

Industrial and Labour Notes

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain shows that the total working population at the end of April was 23,265,000 (15,937,000 men and 7,328,000 women), indicating an increase of 36,000 during the month. The total included 818,000 in the Forces.

In civil employment, there were 22,208,000 people at the end of April, which was 55,000 more than at the end of March. Of the April total, 4,128,000 were engaged in the basic industries, the only significant change in this group during the month occurring in agriculture, which added 21,000 to its labour force. For the first time for some months there was no increase in April in coal mining manpower, the number of wage earners on colliery books at the end of the month being 703,000. The total number employed in the manufacturing industries at the end of April was 8,692,000, or 16,000 more than at the end of March. The metals and engineering trades added 4000 to their labour forces during the month, bringing the number to 4,119,000, compared with 4,086,000 at the end of last year.

The Ministry's latest figures of unemployment relate to May 21st, on which day there were 215,682 registered as out of work, compared with 252,952 on April 16th. It is estimated by the Ministry that the number of people registered as unemployed on May 21st represented 1 per cent of the total working population.

The Amalgamated Engineering Union

The National Committee of the Amalgamated Engineering Union is holding its annual meeting in Brighton this week, and was addressed by the President, Mr. Jack Tanner, at the opening session on Monday morning last. Mr. Tanner directed attention to the fact that this year the A.E.U. is commemorating the hundredth anniversary of its parent organisation, the Amalgamated Society of Engineers. The present membership of the Union, he said, was 815,000.

Mr. Tanner then went on to refer to the settlement, last November, of the wage claim which the A.E.U. had initiated in 1949. He said that, while that settlement was by no means satisfactory, it did raise the minimum rate for skilled men by 11s. a week, and brought about some consolidation. But, in effect, "great numbers" of A.E.U. members had not benefited at all because their earnings were already above the new minimum. The result, Mr. Tanner observed, was that much dissatisfaction with the settlement had been expressed. But, he continued, the representatives of the Confederation of Shipbuilding and Engineering Unions (of which the A.E.U. is a part) had no alternative but to accept the recommendations of the National Arbitration Tribunal, since the ballot vote of the members had instructed them to submit the question to arbitration. They pointed out, however, Mr. Tanner claimed, that the settlement would only be acceptable "if it was applied in a flexible and realistic manner." That, he asserted, had not been done in a great many establishments, with the result that there had been many disputes up and down the country and some districts were still endeavouring to get a satisfactory settlement.

Later in his address, Mr. Tanner spoke about the remarmament programme, saying that it raised more sharply than ever the need for a high standard of industrial efficiency. Engineering workers, he declared, could make an extremely valuable contribution to help industry achieve greater efficiency, and thus to get the 4 per cent rise in productivity which the Government hoped for this year. It was high time, Mr. Tanner went on, "that all employers realised that the outworn and outmoded cry of no interference by the workers in managerial functions should have no place in industry to-day." The members of the A.E.U., he claimed, had years of hard practical experience behind them and, given an opportunity, could show almost every management how to improve its efficiency and achieve higher output.

Engineering Wages and Hours

Of the resolutions submitted for consideration by the National Committee of the Amalgamated Engineering Union, more than 100 concerned matters relating to wages and working hours. One of the resolutions dealt with the "Engineers' Charter." It asked that, in view of the tremendously increased productivity in the engineering industry and in order to mark the centenary of the A.E.U., the executive council should "demand from the employers and inaugurate a campaign throughout the membership" for a forty-hour week, equal pay for equal work, two weeks' annual holiday with pay plus all statutory holidays, and a paid holiday in the engineering industry on May 1st. Another resolution said that, having observed the increased productivity in the engineering industry, the executive council of the Union should open immediate negotiations for a forty-hour week with a guaranteed weekly payment of forty hours, without any loss of existing earnings.

During the committee's debate on wages on Tuesday last, a resolution was passed calling for an increase of £1 a week for all manual workers in the engineering and shipbuilding industries. The resolution recommended that the new rate should form the basis for calculating piecework earnings, and that piecework prices should be such as to permit pieceworkers to earn one-third more than the increased time rate.

The B.E.A. Graduate Training Scheme

The British Electricity Authority has announced that the graduate training scheme for technical engineering staff, which it operates in conjunction with the area electricity boards, has been slightly modified to include a period of up to six months' basic mechanical workshop training for students who have not previously had such experience. In view of this amendment the period of training may be two or two and a half years.

The rates of pay have been increased to £330 for the first year of training and £345 a year for the remaining period of training, with an addition of £25 a year for trainees in the London area. In order to qualify for the scheme, a student must possess an engineering degree of a United Kingdom university, or a Higher National Diploma in engineering, or its equivalent, or a Higher National Certificate in engineering, or have passed the associate membership examination of either the Institution of Mechanical Engineers or the Institution of Electrical Engineers. Provision is made in each course for a period of six months' training in the works of a manufacturer of equipment used by the electricity supply industry.

British Overseas Trade

Provisional figures of overseas trade in May show that exports of United Kingdom goods were valued at £229,700,000, a figure slightly below that recorded for April. Re-exports were valued at £11,400,000. The Board of Trade says that exports and re-exports for the first five months of this year were valued at £1,095,900,000.

Exports from this country to the U.S.A. declined to £10,800,000, which was £1,100,000 below the average for the first four months of this year. But exports to the U.S.A. in the period January to May were 24 per cent above the rate of export in 1950, as a whole. Exports of United Kingdom goods to Canada remained high during May and reached a value of £14,400,000, the total value from January to May being 9 per cent above the 1950 rate of export. Taking Canada and the U.S.A. together, exports in the first five months of this year totalled £115,300,000, which represented an annual rate 16 per cent higher than in 1950, but 8 per cent below the rate achieved in the fourth quarter of last year.

There was another increase in May in the value of imports to the United Kingdom. The provisional total was £338,200,000, a figure £48,300,000 above the average for the first four months of this year. Taking the period January to May, inclusive, the value of imports to this country was £1,497,800,000, which was equivalent to an annual rate 38 per cent above 1950.

Restriction on Nickel

Because of the increasing demands of the rearmament programme, the Board of Trade and the Ministry of Supply are banning, from to-day, the use of nickel in the manufacture of a considerable number of articles. This prohibition follows the cuts in nickel supplies for stainless steel production and nickel plating, which were announced by the Minister of Supply in April.

The present restriction is imposed by two Orders, which stop the use of nickel or austenitic stainless steels or nickel alloys in the manufacture of the domestic and commercial goods specified in schedules in the Orders. The principal nickel alloys involved are nickel silver, cupro nickel and monel metal. Makers of prohibited articles listed in the first schedule of the Orders are allowed until October 1st to use up stocks of components, which they may hold at present. A second schedule lists various articles or components, the nickel plating of which is to be prohibited. In order to give manufacturers opportunity to make other arrangements, however, this provision will not come into force until August 22nd.

Under certain circumstances, licences to manufacture prohibited articles may be granted by the Board of Trade and the Ministry of Supply. Further information and advice on this matter can be obtained from the Regional Controllers of the Board of Trade or Ministry of Supply.

International Study of Fire Prevention Methods

The Organisation for European Economic Co-operation is arranging, under its technical assistance scheme, for a team of experts drawn from its member countries to make a European tour for the purpose of studying the subject of fire prevention. It has been stated that £20,000,000 worth of damage is caused annually in the United Kingdom by fire, and that France loses 13,000 million francs a year from the same cause. The loss of resources is believed to be equally high in other member countries of the O.E.E.C.

In making its announcement, the O.E.E.C. says that the emphasis of the team's investigation will be on learning what new approaches, particularly of scientific methods, each member country has to offer in the field of fire prevention, rather than on methods of fire-fighting as such, on which international exchange of information is already satisfactorily organised. The study will be divided into four headings. The first will be operational research, including fire statistics, economic direction, and the education of the general public in fire prevention. Secondly, the experts will compare notes on fire resistance of materials and elements of building construction. Thirdly, they will examine the many different kinds of fire-extinguishing apparatus now in use, and recent development in the use of radio in fire-fighting. Special fire hazards will constitute the fourth subject for investigation. These include the prevention of fire in aircraft, spontaneous heating, dust explosion in manufacturing industries and the extinction of fire in petrol storage tanks and large electrical installations.

The tour is expected to last about one month, the itinerary including the United Kingdom, France, Germany, Italy, the Netherlands and Switzerland.

Notes and Memoranda

Rail and Road

NEW STATION AT CARPENDERS PARK.—Plans for a new passenger station, which is estimated to cost £90,000, at Carpenders Park, between Bushey and Hatch End, on the Watford electric line of the London Midland Region, have been approved by the Railway Executive. The new station will be located about centrally between the housing estates on either side of the line and will involve alterations to the automatic colour light signalling. An island platform 450ft long (with provision for any necessary future extension to 600ft) will be provided immediately south of the present station; it will be 40ft at its widest point, tapering to 20ft at the south end. The two housing estates will be connected by a 12ft wide subway, from which another subway, inclined and of the same width, will serve the island platform.

A TRANSPORT USERS' CONSULTATIVE COMMITTEE.—The Minister of Transport has appointed the Transport Users' Consultative Committee for the South-Eastern area. The members are: Mr. Maurice H. Pugh (chairman), Mr. G. E. Cumming, Mr. C. T. Miller, Lieut.-Colonel C. W. Brannon, Mr. R. J. Davie, Mr. R. S. S. Thomas, Mr. Kaye Don, Mr. A. Dudley, Mr. J. E. Brown, Mr. G. H. Parks, Alderman Colonel Granville Walton, Councillor Colonel the Rt. Hon. the Lord Basing, Councillor A. Sykes, Alderman B. Palmer, Alderman E. M. Ford, Mr. W. H. F. Mepsted, and Mr. F. C. G. Mills. The secretary of the Committee is Mr. C. W. G. Elliff, Commercial Superintendent's Office, Southern Region, Railway Executive, London Bridge Station, London, S.E.1.

NEW TRAIN ARRIVAL BUREAU AT EUSTON.—The new train arrival bureau at Euston Station, which is believed to be the only railway waiting room of its kind in the world, was formally opened on Monday last by Mr. John Elliot, chairman of the Railway Executive. This bureau, which replaces the nearby train arrival indicator, provides the most up-to-date facilities for the large number of people who daily come to meet passengers arriving by train at Euston. In the bureau ninety-two people can sit in comfortable surroundings whilst being supplied with information as to the arrival of the various trains. The principal feature of the interior of the new building is a large screen, divided into twelve panels, on which information about incoming trains is flashed by projectors. Facing the screen are rows of comfortable seats, but anyone in a hurry can see the panels through a long non-reflecting window without having to enter the building. The information covers all the steam trains showing their progress at Rugby and Watford Junction or Tring, and, as each one approaches Euston, the platform at which it will arrive.

Air and Water

ADMIRALTY ENGINE.—A new light-weight diesel engine, designed and produced by Davey, Paxman and Co., Ltd., has been adopted by the Admiralty as a standard unit. The engine, which is of vee design, has its twelve cylinders arranged at an included angle of 60 deg., incorporates the four-valve, direct-injection combustion system and is available in normally aspirated form or turbo-charged.

NEW PORTSMOUTH/ISLE OF WIGHT SHIP.—The new motor vessel "Shanklin," which entered service on the Portsmouth/Ryde, I.O.W., route on June 18th last, is the third new ship to be brought into this service since the war, and, like her predecessors, the "Southsea" and "Brading," is screw driven, replacing a paddle steamer of the same name which was recently withdrawn from service after a successful career of twenty-six years. The vessel has a gross tonnage of 965, a speed of 14½ knots, and is equipped with radar. Accommodation is provided for 1400 passengers.

BRITISH AIRWAYS TRAFFIC.—It is reported that the volume of traffic carried by the British airlines during February, 1951, once again showed a very substantial increase over the corresponding month in 1950. B.O.A.C., B.E.A.C. and their associated concerns together carried 61,348 passengers and flew over 58 million passenger-miles; of these passengers, 45,474 were carried on international routes. On its North Atlantic services, B.O.A.C. carried 3803 passengers, an increase of over 64 per cent compared with February, 1950, and the total number of passengers carried in the month—16,918—shows a corresponding increase of nearly 40 per cent. B.E.A.C. carried a total of 43,668 passengers, an increase of 17.4 per cent, and its freight figures were raised from 563·5 tons in February, 1950, to 773·1 tons in February, 1951.

Miscellanea

FESTIVAL FACTORY IN NORTHERN IRELAND.—A new factory at Castlereagh, Belfast, which at present houses the Northern Ireland Festival of Britain Farm and Factory Exhibition, is to be leased on the termination of the Festival to Short Brothers and Harland, Ltd. The firm proposes to use the factory for light engineering work.

NOTCH BAR TESTING AND WELDED CONSTRUCTION.—The Joint Committee on Materials and their Testing in association with the Institute of Welding, announces that a symposium on recent developments in notch bar testing of materials and their relation to welded construction, will be held in London on Wednesday, December 5, 1951. Papers are being invited from a number of British and foreign experts and will be preprinted and introduced with a view to discussion.

WIRE DATA.—A folder containing wire data sheets has been published by the Aluminium Wire and Cable Company, Ltd., of Port Tennant, Swansea. There are five sheets and the first serves as a broad guide to the selection of wire for a given purpose, by rating the suitability of various aluminium and aluminium alloy wires for certain operations. Data sheets 1B and 2B list the chemical and mechanical properties of non-heat-treatable and heat-treatable alloys, respectively, while sheets 1M and 2M give the same information in metric units.

RURAL ELECTRICITY SUPPLIES.—A statement made recently to the Electricity Consultative Council by Mr. S. F. Steward, chairman of the South-Western Electricity Board, contained the information that 911 farms had been connected with the electric supply system in 1950–51, as against 817 in the previous year. During the nine months ended March, 1951, the Board had connected eighty more farms than the estimate given to the Consultative Council earlier in the year, the actual figures for the period being 730 farms and 6678 other rural premises.

ITALIAN OIL REFINERY.—The Condor oil refinery at Rho, near Milan, which is designed to produce 1,300,000 tons per annum, is expected to be in operation by the end of 1952. The refinery will include an atmospheric distillation plant; a catalytic cracking plant; recovery, separation and purification plants for the liquid and permanent gases produced, and refining plants for liquid gas, petrol, kerosene and white spirit. Storage capacity for 82,000,000 gallons is provided, and a 12in diameter pipe-line 72 miles long will connect the refinery with Genoa where a deep-water dock is under construction.

ATOM EXPORTS.—The Ministry of Supply has stated that Britain's exports of isotopes from the Atomic Energy Research Establishment, Harwell, reached their highest figure in May, with Eire and France as the best customers. During the month 236 consignments left this country by air for destinations ranging from Australia to Eire. In addition, some packages travelled by sea to France. This figure compares with 211 consignments exported in April and 155 in March. It brings the total number of shipments since the beginning of the year to 961, compared with 483 in the same period of 1950.

GAUGE AND TOOL EXPORT CATALOGUE.—The Gauge and Toolmakers' Association has just issued the second edition of its export catalogue. This book is printed in English, French and Spanish, and many thousands of copies are being mailed to actual and potential buyers of British tools and gauges in all parts of the world. Copies are also being sent to H.M. Trade Commissioners, Imperial Trade Correspondents, Diplomatic Correspondents, and to all British Consulates and Embassies overseas. The catalogue will be forwarded free of charge to all destinations abroad, and concerns in Great Britain can obtain copies from the Association offices at Standbrook House, 2/5, Old Bond Street, London, W.1, at 5s. net.

MINING SUBSIDENCE EFFECT ON SMALL HOUSES.—A new report has been issued in the Ministry of Works series of National Building Studies on the work of an Inter-Departmental Committee, investigating methods of preventing or minimising damage caused by surface subsidence to houses in mining areas. It states that complete protection of houses against damage by all movements due to subsidence is generally impracticable and uneconomic. Nevertheless, houses can be made more resistant to mining movements by making a number of simple changes in normal design—without incurring a large increase in cost. The report gives details of some recommended precautions to be taken in the lay-out and construction of houses.

EXHIBITION OF MODERN DOMESTIC APPLIANCES.—A novel form of mobile showroom has been specially designed by the Solid Smokeless Fuels Federation to demonstrate the latest types of domestic solid smokeless fuel appliances. In it eight typical appliances, covering all the heat services in the home, which will be on view, include open fires and heating stoves, cookers, hot water boilers (some of them multiple-duty appliances), and a combination grate for all three services. An appliance of each type can be shown alight and experienced demonstrators will travel with the showroom. This showroom will visit country shows and market towns, and inquiries regarding the itinerary should be addressed to the Federation at 1, Grosvenor Place, London, S.W.1.

Personal and Business

BUTTERS BROS. AND CO., Ltd., states that from June 25th its London address will be the Crane Works, Long Lane, Hillingdon, Middlesex.

MR. R. B. SAWREY-COOKSON has been appointed public relations officer of the British Road Federation, 4A, Bloomsbury Square, London, W.C.1.

MR. J. D. MORTON, M.I.Mech.E., M.I.E.E., has been appointed a director of Siemens-Schuckert (Great Britain), Ltd., Faraday Works, Brentford.

MR. CHARLES HOPE LUMLEY has been appointed director of home sales (industrial) of Sigmund Pumps, Ltd., 52, Grosvenor Gardens, London, S.W.1.

WAILES DOVE BITUMASTIC, Ltd., Hebburn, Co. Durham, announces that Mr. J. E. Taylor, general manager, has been appointed a director of the company.

BURGESS PRODUCTS, Ltd., states that its micro switch division will be transferred, on June 25th, from Sapcote, Leicestershire, to Dukes Way, Team Valley, Gateshead, 11 (telephone, Low Fell 75322).

THE MINISTER OF SUPPLY announces that in order to assist him in discharging his responsibility to promote economy in the use of scarce metals in rearmament production and in the engineering industries, he has appointed Mr. D. A. Oliver, director of research at the Birmingham Small Arms Company, Ltd., to serve part time as Metals Economy Adviser. Mr. Oliver will also be available to advise the Lord Privy Seal on questions of economy in use arising in connection with the supply of non-ferrous metals.

Launches and Trial Trips

LUDOVIC PIERRE, motor trawler; built by Les Chantiers et Ateliers Augustin Normand, for Pêcheries de Cornouaille; length between perpendiculars 32m, breadth moulded 7m, depth moulded 4·05m; M.A.N. four-cycle, single-acting, mechanical-injection diesel engine, six cylinders 450 b.h.p. at 207 r.p.m. Launch, May 22nd.

BRIMSDOWN, steam-driven collier; built by the Burntisland Shipbuilding Company, Ltd., for the British Electricity Authority; length between perpendiculars 257ft, breadth 39ft 6in, depth moulded 18ft 6in, deadweight 2680 tons, draught loaded 17ft 1½in; three self-trimming holds, steam deck machinery; "North-Eastern Reheat" direct-acting, triple-expansion steam engine, 800 i.h.p. at 78 r.p.m., taking steam from one coal-burning cylindrical, multi-tubular boiler. Trial, May 30th.

PORT ADELAIDE, refrigerated cargo liner; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the Port Line, Ltd.; length between perpendiculars 460ft, breadth moulded 64ft 6in, depth moulded to upper deck 41ft 6½in, deadweight 10,700 tons, insulated cargo 365,000 cubic feet, general cargo 225,000 cubic feet; Hawthorn-Doxford oil engine, six cylinders 725mm diameter by 2250mm combined stroke, 7500 b.h.p. at 112 r.p.m., two auxiliary composite vertical boilers, three W. H. Allen 300kW generators; service speed 15¼ knots. Trial, May 31st.

Contracts

VICKERS-ARMSTRONGS, Ltd., has received an order for a 32,000 tons deadweight oil tanker from the "Alvion" Steamship Corporation, of Panama. The vessel will have a length between perpendiculars of 630ft, a breadth moulded of 85ft 6in by 46ft 6in deep, and will be propelled by geared turbine machinery of 12,500 s.h.p. to maintain a service speed of 14¼ knots. A repeat order of the motor tanker "Credo" has been placed by Mr. George P. Jensen, of Norway. The ship will be 565ft length between perpendiculars by 80ft breadth moulded by 42ft 6in deep, and have a service speed of 13 knots, the propelling machinery being a Vickers-Doxford oil engine of 6600 b.h.p.

British Patent Specifications

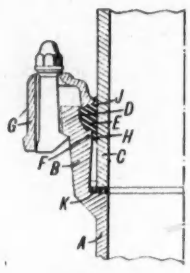
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

TUBE AND PIPE COUPLINGS

653,127. July 27, 1948.—Joint for Protecting Underground Metal Pipes from Stray Electric Currents, Compagnie de Pont-a-Mousson, of Place Camille Cavallier, Nancy, France.

According to the drawing the piping is formed as usual with pipes of a length of 4m to 8m. Each of the pipes *A* is provided with a bell *B*, which penetrates the cylindrical spigot *C* of the adjacent pipe. In the bell, from the free end to the bottom, a housing *D* is provided for a washer *E* of rubber or material having non-conducting electrical properties, a bearing surface *F* for centring the pipe *C*, and a frusto-conical surface, the diameter of which increases towards the bottom of the bell to enable angular deflections of a pipe relatively to the other. A clamping collar *G*, held by bolts, is pressed against the washer. The face of the washer *E* in contact with the spigot of the pipe is extended by two circular tongues *H* and *J* of trapezoidal cross section. The tongue *H* is inserted between the centring surface and the spigot of the tube and the tongue *J* between the inner side face of the clamping



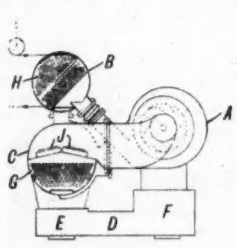
No. 653,127

collar and the spigot. Between the end edge of the spigot of the pipe and the bottom of the bell is a free space which can be filled by a thin slab *K* of tarred wood or any other electric insulating material. When the joint described is made, the free space or the plate *K* insulates electrically the bottom of the bell from the edge of the spigot of the pipe. On the other hand, the tongues *H* and *J* respectively insulate the spigot from the centring surface and from the face of the clamping collar. A complete electric insulation is thus obtained between the body of one of the pipes and the bell-clamping collar assembly of the other pipe. These results are obtained without any diminution of the possibilities of angular deflection between piping elements under the action of the ground movements.—*May* 9, 1951.

REFRIGERATING MACHINERY

652,680. July 30, 1947.—Refrigeration Plant, The Carrier Corporation, of 300, South Geddes Street, Syracuse, 1, New York, U.S.A. (*Assignees of Walter Jones*).

This invention relates to centrifugal refrigeration with a compressor assembled in combination with



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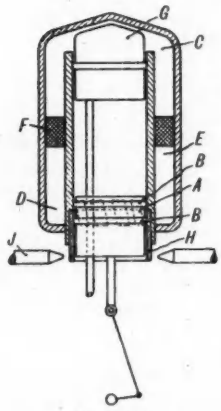
an evaporator, a condenser and related auxiliary elements. The drawing shows an assembly of apparatus including a centrifugal compressor *A*, employing a suitable refrigerant, a condenser *B*, and an evaporator or cooler *C*, all assembled upon a bed *D* having two longitudinal base portions *E* and *F*. The cooler and condenser are of the shell and tube type. In the cooler, the brine or other fluid to be cooled, e.g., water, flows through tubes *G*, while in the condenser the cooling water flows through tubes *H*. The refrigerant cycle starting at evaporator or cooler is as follows:—The brine or water to be cooled flowing through the tubes is warmer than the refrigerant in the shell surrounding the tubes. As a result, the refrigerant is evaporated at a temperature corresponding to the pressure in the evaporator. The refrigerant, in resultant vaporous form, passes through eliminators *J* into the suction of the compressor *A*. The compressor normally has a number of stages of compression, and the compressed gas discharged from the last stage enters the condenser at a point near the bottom as shown. The refrigerant discharged by the compressor into the condenser condenses on the outside of tubes *H* at a temperature corresponding to the condenser pressure, the heat of condensation being transferred to the condenser water. The liquefied refrigerant from the condenser drains down an inside conduit into an economiser. From the economiser the refrigerant in liquid form is routed to the cooler to complete the cycle.—*May* 23, 1951.

AIR ENGINES

652,863. December 12, 1946.—Lubrication of Piston Engine Cylinders, N. V. Philips' Gloeilampenfabrieken, Emmasingel, Eindhoven, The Netherlands.

The drawing shows a cylinder of an air or hot gas engine in which a piston *A*, together with piston rings *B*, is adapted to move. A hot chamber *C* freely communicates with a cold chamber *D* through a channel *E*. Inside the channel *E* is a regenerator *F*, having a large number of small pores. In the cylinder there moves a displacer *G* coupled to the crank in a manner which is not shown in the drawing. According to the invention, a ring *H* of self-lubricating metal is provided in the wall of the cylinder. It projects a little from the cylinder wall and may be moistened by the splashing oil from the crankcase. As an alternative, the ring may be moistened by one or more sprinklers *J*, spraying a thin squirt of oil against the ring. Owing to the porosity of the metal of the ring the oil is absorbed, the lubricant being distributed substantially regularly over the cylinder wall by the piston. Instead of the ring, it is also possible to provide one or more strips of self-lubricating metal in the axial direction in the wall of the cylinder or, if desired, the body of porous self-lubricating metal may be



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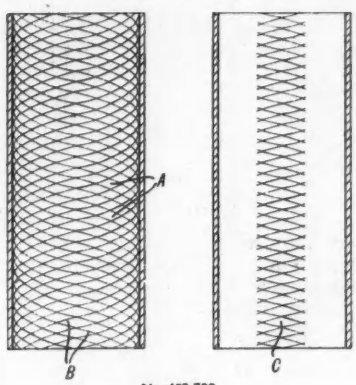
completely enclosed in the cylinder, the supply of oil coming from a container outside the body. —*May* 2, 1951.

BEARINGS AND SUPPORTS

653,708. August 12, 1948.—Chromium-Plated Cylindrical Bearing Surfaces, Stanley Hedgecock, of 139, Victoria Road, London, N.22, and Laystall Engineering Company, Ltd., of 53, Great Suffolk Street, London, S.E.1.

The invention concerns chromium-plated cylindrical bearing surfaces and particularly cylinder bores, and comprises an improved chromium-plated cylinder surface having good oil-retaining properties. In the drawings the left-hand view is a section of a cylinder liner having its whole surface formed into grooves or channels according to the invention. On the right hand is a section of a cylinder liner having the grooves or channels confined to the thrust faces of the cylinder liner. In manufacture, the liner is first chromium-plated and finished to the dimensions required. The helical grooves or channels are then cut in the plated surface by means of diamond chips embedded in a tool which is rotated and traversed axially relatively to the plated surface. The tool is operated so as to produce two sets of helical grooves or channels of opposite hand which intersect so as to produce islands *A*, each of which is surrounded by a continuous channel formed by the helical grooves *B* cut in the surface of the chromium-plating. The grooves preferably have a



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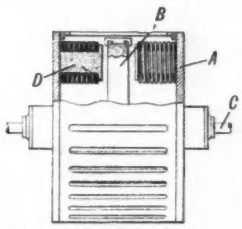
depth of approximately twenty-four millionths of an inch. A modification in which the channels or grooves are confined to the thrust faces of the cylinder liner, one of which faces is constituted by the area marked *C*, is also shown.—*May* 23, 1951.

ELECTRICAL ENGINEERING

653,758. April 14, 1948.—Electric Brakes, Société Electro Mecanique de L'Aveyron, of Route de Severac, Rodez (Aveyron), France.

The invention relates to electric brakes (especially for vehicles), in which the speed reducing effect is obtained by eddy currents created in a rotor, preferably of a magnetic material, revolving in the electro-magnetic field of electro-magnets. As shown in the accompanying drawing the brake includes a carcase *A* fixed to the frame of the vehicle and housing a magnetic metal rotor *B* which is rigid with



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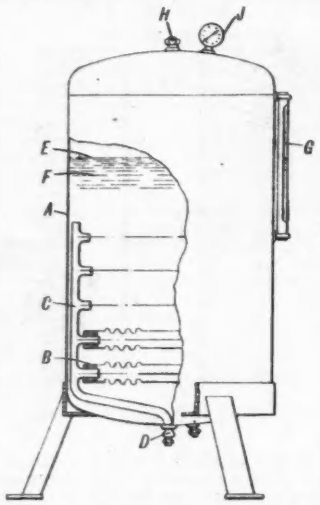
a shaft *C* subjected to the braking action. Inside the carcase *A*, on either side of rotor *B*, are fixed electro-magnets, each of which consists of a pole piece *D* and an insulated winding or coil. This coil may be connected, through a switch, with a source of current. When current flows through the coils the rotor which revolves together with the shaft is subjected to a powerful braking effect corresponding to the creation of eddy currents inside the rotor. The energy of the eddy currents is transformed into heat, which is to be dissipated into the surrounding air. The methods of construction are fully described in the specification.—*May* 23, 1951.

653,729. March 1, 1950.—Tanks or Reservoirs for Feeding Oil to Electric Cables, Pirelli Societa per Azioni, of Viale Abruzzi 94, Milan, Italy.

Referring to the drawing, *A* represents a rigid metallic tank, *B* represents one of a number of flexible walled cells or drums which are in communication with one another through a pipe *C* and contain insulating cable oil. These cells constitute a reservoir. As will be seen from the drawing, the cells *B* are located in the tank *A*, from which the cell-interconnecting pipe *C* carries the insulating oil to the cable through the outlet *D*. In addition, the tank is filled up to a certain level *E* with another liquid *F*, which preferably is an oil similar to that contained in the cable. A sight glass tube *G* indicates the liquid level. The liquid *F* is entirely separated from the cable insulating oil in the cells *B*. This external oil has two functions: first, it protects the flexible diaphragms of the cells against corrosion, as they always remain completely submerged in the external oil; and secondly, it provides a fairly accurate measurement of the volume of oil contained in the flexible cells. The pressure above the

external oil may be only atmospheric or, if desired, a higher pressure may be maintained by compressed gas. For this reason the outlet *H* at the top of the tank can either be placed in



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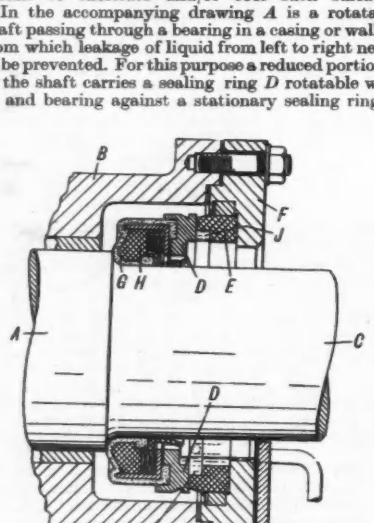
communication with the outside air through a suitable air drier and filter or may be connected with a gas compressor, in which latter case the pressure is indicated by a manometer *J*.—*May* 23, 1951.

SHAFT GLANDS AND SEALS

653,939. July 15, 1948.—Sealing Between Rotating and Stationary Machine Parts, Crane Packing, Ltd., and Samuel Clifford Walter Wilkinson, of the company's address, Slough.

This invention relates to sealing between the surfaces at thrust bearings, pump shafts, and the like, and has for its chief object to provide improved means to lubricate and/or cool such surfaces.

In the accompanying drawing *A* is a rotatable shaft passing through a bearing in a casing or wall *B*, from which leakage of liquid from left to right needs to be prevented. For this purpose a reduced portion *C* of the shaft carries a sealing ring *D* rotatable with it, and bearing against a stationary sealing ring *E*



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carried by an annular plate *F* attached to the outer face of the wall. The sealing ring is carried on the shaft portion by a flexible ring *G* of substantially U-shaped cross-sectional form enclosing a filler ring *H* and a set of springs, which constantly urge the rotary sealing ring against the stationary ring. Between the rings at the inner zone of their interfaces is an annular groove or channel *J* serving as an arcuate well for containing a liquid when the shaft is at rest. When the shaft is rotated the liquid will become distributed all round the groove. In order to maintain a considerable volume of liquid in a static condition when the shaft is stationary, means are provided to form an enlargement of the reservoir for the static liquid.—*May* 30, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Association of Supervising Electrical Engineers

Mon., June 25th.—Bournemouth Branch: Grand Hotel, Firvale Road, Bournemouth, Lecturettes by members, 8.15 p.m.

Incorporated Plant Engineers

Tues., July 3rd.—Birmingham Branch: All-day visit to Manchester Oil Refineries and Petrochemicals, Ltd.

Institution of Mining Engineers

Wed. to Fri., July 4th to 6th.—Summer Meeting, Nottingham.

Institution of Sanitary Engineers

Fri., July 6th.—Caxton Hall, Westminster, S.W.1, Annual General Meeting, 5.15 p.m., "From Thames to Tap," Gordon Carter, 6 p.m.

Sat., July 7th.—Visit to Metropolitan Water Board Laboratories, New River Head, Rosebery Avenue, E.C.1, 9.45 a.m.

International Conference of Naval Architects and Marine Engineers, 1951

Tues., June 26th.—London: Central Hall, Westminster (Great Hall), "Ships' Structures; A Century of Progress," R. B. Shepheard; "B.S.R.A. Resistance Experiments on the 'Lucy Ashton,' Part I: Full-Scale Measurements," Sir Maurice E. Denny, Bt., 10 a.m.

Wed., June 27th.—London: Central Hall, Westminster (Lecture Hall), "Higher Steam Conditions for Ships' Machinery," Mark L. Ireland, H. W. Semar and N. L. Mochel; "Boiler and Turbine Testing," L. F. Ingram, L. A. B. Peile, 9.45 a.m.

Thurs., June 28th.—London: Central Hall, Westminster (Lecture Hall), "Marine Fuel Oils," M. Blanchier; "Ship Motions," John C. Niedermair, 10 a.m.; "Proposed Design for a Combined Research Training and Cargo Ship," H. E. Jaeger, J. C. Arkenbout Schokker; "Some Aspects of Prefabrication in Ship Construction," Nils Eckerbom, 2.30 p.m.

Thurs., July 5th.—Newcastle upon Tyne: Literary and Philosophical Society, Westgate Road, "U.S. Fleet Maintenance and Battle Damage Repairs in the Pacific during World War II," Ralph K. James; "Stresses in Propellers and Propeller Shafting under Service Conditions," S. F. Dorey, 10 a.m.

Manchester Geological and Mining Society

Thurs., June 28th.—Summer Excursion to Penmaenmawr Colliery, 9 a.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

ROUND STRAND STEEL WIRE SUSPENSION ROPES FOR LIFTS AND HOISTS

No. 329 : 1951. This revision, which was previously revised in 1939, was undertaken at the request of the Lifts, Hoists and Escalators Committee for the inclusion of eight-strand ropes and ropes having a tensile range of 70 to 80 per square inch, the tensile ranges now included being 70 to 80 and 80 to 90 tons per square inch. A departure from previous practice is that this revision now expresses the size of rope by the diameter and not by the circumference, a change which is considered to be in the best interests of all concerned and which brings British practice into conformity with the current practice in other countries. The foreword gives comprehensive guidance on the use of these ropes and gives recommendations for the diameters of drums, sheaves or pulleys. The body of the standard is substantially similar in lay-out to the previous standard, the rope constructions included in it being 6 by 19, 6 by 19 with six filler wires, 6 by 19 Seale, 8 by 19, 8 by 19 with six filler wires and 8 by 19 Seale. It includes testing requirements, breaking loads and weight of the ropes. Price 3s., post free.

TERMINALS FOR RAILWAY SIGNALLING APPARATUS

No. 442 : 1950. This standard, which has recently been published, is a revision of a British Standard first issued in 1932. It has been revised to take into account recent developments in design and manufacture, and now applies to main terminals on electrical apparatus for railway signalling, but not terminals inside the apparatus; it covers the nut type, the screw type and the insulated screw type; materials, dimensions and manufacturing requirements are specified. Price 2s. post free.

Technical Reports

The Thermal Expansion of Concrete. National Building Studies Technical Paper No. 7. D.S.I.R. London: H.M. Stationery Office. Price 1s. 3d.—This paper describes an investigation made by the Building Research Station with the collaboration of the Institution of Civil Engineers, to obtain precise information on the thermal expansion of concrete, for which the values hitherto reported showed considerable divergence. The investigation included measurements of the coefficient of linear thermal expansion of concretes made with various aggregates commonly used in Great Britain, and of the way in which these values vary with different cements. The effect of the mix proportions on thermal expansion was also investigated, as well as the effects of the age of the concrete, of the conditions of curing, and of wetting and drying the concrete specimens after curing. The results of the various tests are given in a number of tables and are discussed in relation to the values obtained in other investigations.

Books of Reference

Ship and Boat Builder Year Book. London: John Trundell (Publishers), Ltd., Temple Chambers, Temple Avenue, E.C.4. Price 25s. net.—The second edition of the "Ship and Boat Builder Year Book," recently published, is an invaluable work for all those who go down to the sea in little ships. Besides giving a comprehensive survey of everything connected with the owning, building and equipping of small craft, the book includes a number of authoritative articles upon subjects directly related to small boats. Subjects covered include the design of yachts, dredgers and lifeboats. Such items as marine engine production, plastics and marine paints, the changes in coastal navigation and problems of yard insurance are also discussed. In the reference section of the book there are: directories of builders' yards and suppliers of equipment, relevant British Standards and lists of consultants, associations, and of British and foreign owners of small craft. Finally, there are lists of considerable value to those engaged in boatbuilding and allied trades, of world dock and harbour authorities, and of commercial diplomatic officers and trade commissioners.

Catalogues

Crane, Ltd., 45–51, Leman Street, London, E.1.—Leaflet giving particulars of the Crane gunmetal renewable disc radiator globe valve.

Cambridge Instrument Company, Ltd., 13, Grosvenor, Place, London, S.W.1.—Folder No. 65 A, giving details of mercury-in-steel thermometers.

Chloride Batteries, Ltd., Exide Works, Clifton Junction, near Manchester.—Booklet entitled "Exide Ironclad," for all types of battery traction.

Muirhead and Co., Ltd., Elmers End, Beckenham, Kent.—Bulletin "B-668-B," describing picture transmitters for operation on telephone circuits.

The Electric Meter Company, Castor Road, Brixham, S. Devon.—Catalogues dealing with meters designed for the home and export markets.

James Archdale and Co., Ltd., Ledsam Street, Birmingham.—Brochure showing machines actually in operation in customers' works.

Tangyes, Ltd., Cornwall Works, Birmingham.—Catalogues illustrating a series of horizontal diesel engines and a variety of hydraulic lifting jacks.

English Steel Corporation, Ltd., Sheffield, 9.—Publication giving information on the application, manipulation and heat-treatment of tool steels.

Howard Clayton-Wright, Ltd., Wellesbourne, Warwickshire.—Leaflet describing and illustrating the "Clayflex" vibro damper or anti-vibro mount.

Dowding and Doll, Ltd., Greycoat Street, Westminster, London, S.W.1.—Catalogue describing the American-built Cleereman lay-out drilling machine.

Kestner Evaporator and Engineering Company, Ltd., 5, Grosvenor Gardens, Westminster, S.W.1.—Brochure dealing with chemical plant and processes.

British Timken, Ltd., Cheston Road, Aston, Birmingham.—Pictorial record of a British Timken axlebox after 2,000,000 miles' service on Egyptian State Railway.

Remington Rand, Ltd., Commonwealth House, 1–19, New Oxford Street, London, W.C.1.—Illustrated catalogue dealing with office furniture and equipment.

Chloride Batteries, Ltd., Exide Works, Clifton Junction, Near Manchester.—Illustrated catalogue dealing with Exide batteries for diesel engine starting.

Keith Blackman, Ltd., Mill Mead Road, Tottenham, London, N.17.—Publication No. 20, "Fan Engineering Equipment"; publication No. 21, "Extravent Window Fan."

Andre Rubber Company, Ltd., Kingston By-Pass, Surbiton, Surrey.—Catalogue of photographs illustrating the application of rubber to engineering and industrial needs.

Automatic Telephone and Electric Company, Ltd., Strowger Works, Liverpool, 7.—Publication No. 1143, dealing with the "Soundmaster Intercom" system.